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CONSTRUCTIONAL ENGINEERING

VOL. XIV. 1919. Nos. 1 to 12.

A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

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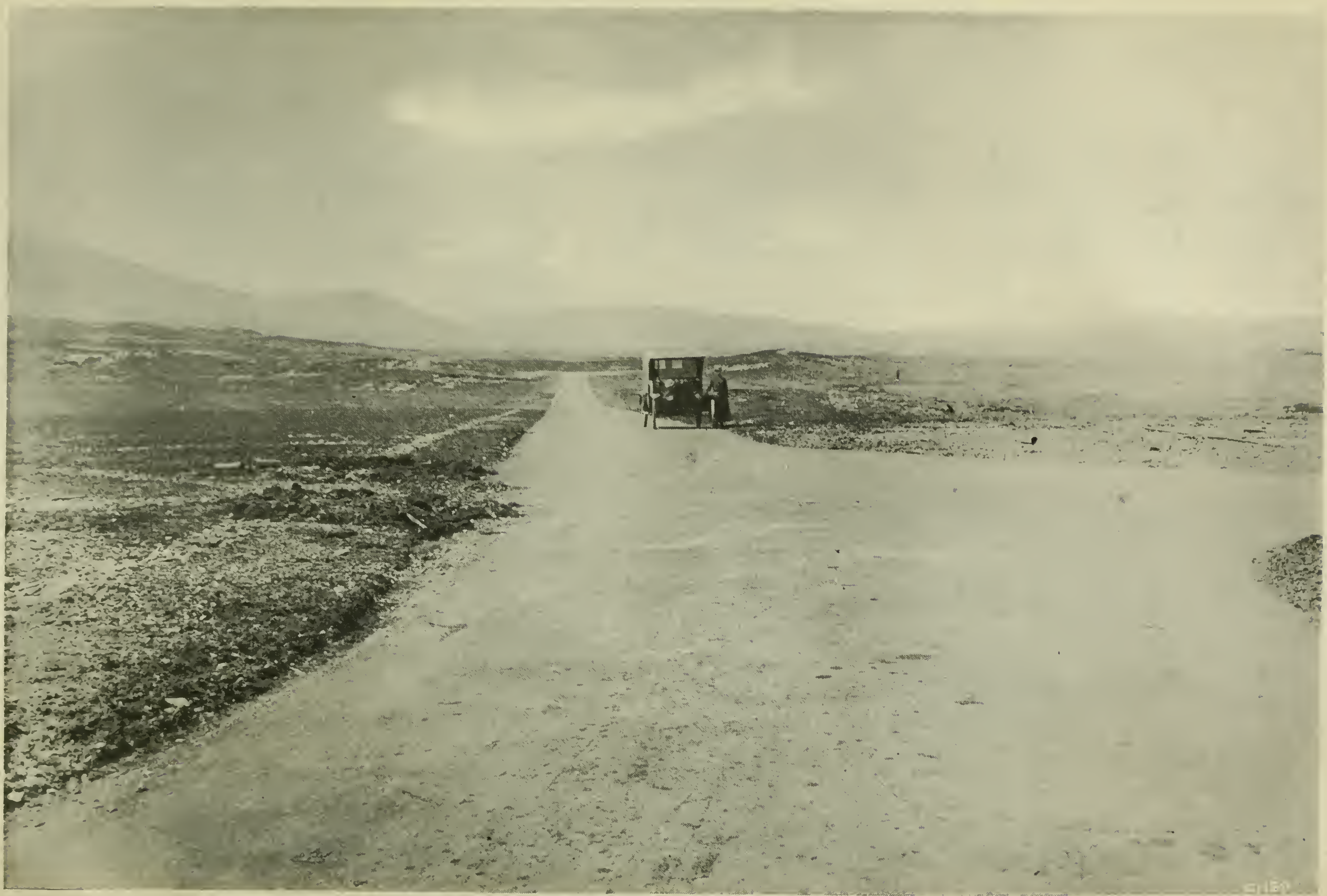

A Reinforced Concrete Road, Loch Doon Camp.
[*For Description see page 43.*]

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EDITORIAL NOTES.

CEMENT FOR COTTAGE DEVELOPMENT.

FROM paragraphs which have appeared in the Press from time to time, and from statements made by various speakers on the public platform, it appears that there is a prevailing fear concerning the question of the supply of cement for the 300,000 cottages which will probably be erected during the next few years.

Assuming that 70,000 cottages will be erected during each of the next five years, it is estimated this will require about 280,000 tons of cement annually. Although this may seem a large quantity, it is considerably less than 10 per cent. of the probable total production of the United Kingdom, which should exceed well over 3,000,000 tons per annum, provided that the necessary labour and coal is forthcoming.

From these facts one can gather that there is no reason either to fear a shortage of supply of cement or for any necessity for Government control of this material.

We would also add that the control of distribution of cement by the War Office by means of priority certificates has now been ended. Manufacturers and merchants may now execute orders without any certificate, provided that Government orders receive priority. The export of cement will continue to be governed by export licences.

RELATIONS BETWEEN ARCHITECTS AND SPECIALIST ENGINEERS.— REPORT OF THE SPECIAL COMMITTEE OF THE CONCRETE INSTITUTE.

A feature of Mr. Searles Wood's Presidential address before the Concrete Institute was his presentation of the Report of the Special Committee of the Concrete Institute on the Relations between Architects and Specialist Engineers, a subject of outstanding importance for post-war work. The Special Committee had the benefit of the chairmanship of Sir Henry Tanner, C.B. (late principal architect of H.M. Office of Works).

The report, as presented, is published in this issue, and its outstanding feature, which speaks for itself, is that the Committee considers that when an architect desires to employ an engineer to design and supervise the erection of reinforced concrete or steel frame construction, the client should pay an additional percentage on that portion of the work. The Committee is further of the opinion that the logical procedure would be for the architect to select a specialist engineer who would design his side of the work in consultation with him. They hold that bills of quantities of the special work should be prepared and issued together with the general work.

Broadly speaking, it would appear from the report that the architect is to be responsible for the whole structure, and, given such specialist advice as is deemed necessary, the architect is to be paid an increased fee to cover his outlay on this special advice.

There cannot be the least doubt that this recommendation is a reasonable and practical one, but whether—with the existing custom that has unfortunately grown up and the habit of the public of believing that they should get every form of architectural service for an all-round 5 per cent.—it would be feasible to bring this practice into operation is a very different matter. It might be possible that if the Royal Institute of British Architects took a definite attitude in the matter, and obtained the co-operation of the Society of Architects, and also of its own Allied Societies in the provinces, something could be achieved; but there is no use blinking at the fact that, particularly in the provinces, where such specialist work is largely required on industrial structures, such as mills and factories, the architect, in practice, may object to anything of the kind, as he finds the present custom suits his purpose—namely, that of providing his client with all these etceteras for the inclusive fee of 5 per cent. (whisper not the word how often it is 4 per cent. in the provinces), whilst he, in turn, throws the work upon the specialist contractor who has tendered, who again in turn includes in his tender for the cost incurred in his own office and/or by the specialist designer with an overall extra for establishment charges—*i.e.*, the expense incurred on unsuccessful estimates and wasted effort generally.

It is obviously illogical that every contract in every part of the United Kingdom undertaken by specialist contractors should bear a proportion of what should be professional charges payable by the client on an individual structure. It is yet more illogical that by the immeasurable amount of duplication of work, the waste of labour and effort is multiplied, and the ratio of cost increased on the structures, but then logic is not exactly a feature in the architect's curriculum or practice, or, as a matter of fact, in the building industries generally.

THE CONCRETE INSTITUTE EXAMINATION.

INTRODUCTION.

The subject of examinations is rather fascinating, in addition to being very important, and a great deal has been written and said as to the advisability of examinations in technical subjects, some persons holding the view that no true test of a man's ability can be given by the usual method of examination. There may be some shadow of the truth in this contention, but at the same time there is no doubt that a person who is fully qualified in any subject will experience little difficulty in convincing the examiners of his ability, and he will be successful even if he has not done full justice to himself.

Candidates can be divided into two classes—viz., (*a*) those who have a natural gift for examination, and (*b*) those who cannot express themselves clearly when faced by an examination paper, due to nervousness or other peculiarities of temperament. Now it may be argued that many skilful and well-trained persons will come into the second class, and, as they will not do themselves justice, their examinations are not a fair test, but we are inclined to take a rather different view. Examinations for the purpose of obtaining membership of a professional society are necessary, because a certain minimum standard must be maintained if the society is to carry any influence generally, and the person who is unable to pass an examination in those subjects connected with his occupation will undoubtedly be unable to do himself justice in the discharge of his professional duties, when he will come in contact with clients and other professional men who will, probably unconsciously, be continually testing his knowledge on various matters. The qualifications for entry into a good society should, therefore, consist not only of a knowledge of certain subjects, but also the power to make a proper use of such knowledge, and it is here that the examination is valuable, as it will disclose any weakness in this direction. Every professional man, be he engineer, architect, or lawyer, must be a good business man if he is to serve his client well, and a good business man who has studied his subject will always be able to pass an examination in this subject.

THE CONCRETE INSTITUTE SYLLABUS.

The passing of an examination is now necessary to obtain membership of the Concrete Institute, and the introduction of this restriction is commendable for the reasons given above, and at the same time it will have the effect of raising the prestige of the Institute, thus making membership a thing to be sought after on account of the distinction.

The examination is divided into two parts, the first of which must be passed before the candidate can be registered as a student, and the second before full membership is attained.

The syllabus has been carefully prepared to cover all the essential subjects in which engineers must be qualified, and at the same time certain selective subjects are wisely introduced to allow candidates who have specialised in any particular branch to take advantage of their special knowledge in the examination.

Part I. Compulsory Subjects.—The first compulsory subject in Part I covers the principles of statics and the theory of structure, and the syllabus reads as follows :—

> Forces acting on a rigid body ; composition and resolution of forces ; couples ; moments of forces ; conditions of equilibrium, with application to loaded structures. Graphical and analytical treatment of the foregoing. Centre of gravity ; specific gravity.
>
> Graphic and analytic methods for the calculation of bending moments, shearing forces, and the stresses in individual members of framed structures loaded at the joints ; reciprocal diagrams ; incomplete frames and redundant members ; buckling of struts ; effect of different end fastenings on their resistance ; combined stresses ; section modulus ; methods of dealing with statically indeterminate problems, as beams supported at three points, etc. ; travelling loads ; rigid and hinged arches ; stresses due to weight of structures ; theory of earth pressure and of foundations stability of masonry and brickwork structures.

It will be seen that all the essential principles are to be mastered by the student, and a good ground work must be acquired, which will enable him to proceed with intelligence to the consideration of the application of such principles to actual problems in construction.

The second subject deals with the strength and elasticity of materials, and here again the items are such that the candidate must cover sufficient matter in his studies to equip himself thoroughly for the second part of the examination. The extract here given shows the portion of the syllabus relating to this subject.

> Physical properties and elastic constants of cast iron, wrought iron, steel, timber, stone, concrete, cement, and other materials ; relation of stress and strain ; limit of elasticity ; yield-point ; Young's modulus, coefficient of rigidity ; extension and lateral contraction ; resistance

within the elastic limit in tension, compression, shear, and torsion; strength and deflection in simple cases of bending; beams of uniform resistance; reinforced concrete beams.

Ultimate strength with different modes of loading; plasticity and permanent set; working stress; phenomena in an ordinary tensile test; stress-strain diagrams; suddenly applied and impulsive loads; resilience; fatigue of metals; effects of hardening, tempering and annealing.

Forms and arrangements of testing machines for tension, compression, torsion, and bending tests; instruments for measuring extension, compression, and twist; forms of test-pieces and arrangements for holding them; methods of ordinary commercial testing; percentage of elongation and contraction of area; test conditions in specifications for the principal materials of construction.

It will be noticed that the candidate is required to know and understand the various methods of testing and how these should be specified, and this we consider very important, as it entails a certain amount of what may be termed practical investigation that is often neglected by students.

Selective Subjects.—These are five in number, and each candidate must take two of these in addition to the compulsory subjects just mentioned.

The subjects are given under the headings of: (1) Chemistry; (2) Physics; (3) Hydraulics; (4) Geology; and (5) Geodesy; and the following are the items which the candidate must be conversant to satisfy the examiners:—

Two of the following subjects must be taken in addition to the compulsory subjects:—

3. CHEMISTRY.

Constitution of matter; chemical elements; Dalton's atomic theory; Newland's law of octaves; Mendeleeff's law of periodicity; modes of chemical action; atomicity; analysis and synthesis; composition of materials employed in structural engineering.

4. PHYSICS. (Note.—A candidate taking this subject must be prepared to answer questions in three of the five sections.)

Sound.—Nature of sound; pitch, intensity, and timbre; transmitting media; velocity of sound; sound waves; vibrating strings, plates, and membranes; resonance; interference; reflection and absorption of sound.

Light.—Theories of light; transmitting medium; velocity of light; solar spectrum; laws of reflection; photometry; candle-power; candle-feet; absorption of light; colour; polarized light; action of lenses; telescope and microscope.

Heat.—Sensible and latent heat; thermometers; pyrometers; effect of change of temperature in solids, liquids, and gases; transfer of heat; radiation; conduction and convection; relative conductivity; thermal units; Joule's equivalent; thermal capacity; specific heat; combustion.

Magnetism.—Magnets; magnetic phenomena; magnetic field; polarity; the mariner's compass; magnetic meridian; deviation and declination of the compass; inclination or dip; induction; galvanometers.

Electricity.—Static and voltaic electricity; induction; conductors; electro-negative and electro-positive elements; electrolysis; lightning; system of electrical transmission; electrical units; measurement of electrical work; Ohm's law; principles of arc and incandescent lighting.

5. HYDRAULICS.

Pressure on surfaces; centre of pressure; strength and stability of structures supporting water pressure; laws of fluid friction; impact of water on surfaces; storage of water and construction of reservoirs.

6. GEOLOGY.

Classification of rocks; succession of strata in aqueous formations; explanation of geological terms; glacial drift; conditions of deposition in fresh and sea water; denudation; disintegration and chemical decomposition of rocks; method of dealing with bad ground for engineering works.

7. GEODESY.

The theory, structure, and adjustment of the principal surveying and levelling instruments and the principles of their employment under various conditions; land surveying; contouring, levelling and use of theodolite.

Of these subjects chemistry, hydraulics, and geology will generally prove the most beneficial to the student, and probably hydraulics and geology will be the two most frequently selected. The last item in the chemistry syllabus is extremely important, as this asks for a knowledge of the composition of materials employed in structural engineering, and we are inclined to consider that a proper understanding of this matter should be compulsory instead of optional, as it is impossible to deal intelligently with a material unless its composition is known and its possibilities and limitations can be fully realised. Again, although hydraulics is an optional subject, it will be seen that a knowledge is essential in Part 2 of the examination, and thus it becomes compulsory before full membership is obtained, as it rightly should do.

To the candidate who is intending to specialise in reinforced concrete work, geology is a necessary subject, and the person who neglects this matter will be seriously handicapped in actual practice when he is called upon to consider various aggregates and their respective merits and demerits.

Part 2—Technical.—The second part of the examination is devoted to three subjects, of which one is compulsory, and of the other two the candidate can make a selection according to his desire to pursue reinforced concrete or steel-frame construction. This is an excellent arrangement, as the compulsory subject deals with structural engineering generally, and herein are the items which cover all those points which are common to all structural engineering regardless of the class of material used, and in addition some knowledge is required of rolled steel sections and other matters which will have to be dealt with in practice by every engineer, even if he elects to specialise in reinforced concrete work. The items in this compulsory subject are here given, and it will be seen that they are comprehensive.

8. STRUCTURAL ENGINEERING (Generally).

Materials of construction; loads—dead loads (distributed and concentrated), live loads (rolling and suddenly applied); bending moments; resistance moments; stresses and strains; shear stresses; deflection; secondary stresses; fatigue of metals; safety factors; wind pressures; standard sections of rolled steel; properties of sections; girders—rolled sections (simple and compound), plate web and lattice web, trussed frame; pillars, columns, stanchions, piers and struts generally; eccentric loading; fixity of ends; roofs—symmetrical and unsymmetrical trusses; connection of parts; bridges—girder, suspension, cantilever; arches—elastic rib, rigid and braced, two and three pivoted; methods of erection; testing and inspecting materials of construction; effect of workshop processes on steel; mass retaining walls and their stability against water pressure and earth pressure; pressures in silos, bins, and hoppers.

The subject includes beams, columns, girders, roofs, bridges, retaining walls, silos, bins, and hoppers, and we consider that the candidate who conscientiously studies all the matter required under the syllabus will be thoroughly trained in all the essentials of structural engineering.

Reinforced Concrete Construction.—This section will be taken by the engineer who is engaged on this class of work, or is likely to be so, and the syllabus should obviously cover the whole field of reinforced concrete design and execution. The items are here reproduced, and it will be noticed that there is a generality about the details specified which might lead the candidate to underestimate the amount of training necessary to ensure success, unless, of course, it is the intention of the examining body to deal with a portion of the subject only. The syllabus is as follows:

9. REINFORCED CONCRETE CONSTRUCTION.

General principles; advantages and disadvantages of reinforced concrete; materials of construction and their testing; nature and properties of materials for concrete; mixing concrete by hand and machine; effect of frost and precautions to obviate damage; laying concrete; testing actual concrete used; testing completed structures; failures and causes; comparison of cost with other methods of construction; fire-resisting properties; causes affecting expansion and contraction; surface finish; durability and maintenance; form work (centreing, shuttering, strutting, moulds, etc.), precautions in fixing, order and periods of removal.

Routine of designing; arrangement of roof and floor slabs, cross beams, main beams, and pillars; loads on floors; calculation of reinforcement for various parts; loads on foundations; rough estimates of cost; rules and regulations.

We consider that the proper preparation of working drawings should be mentioned as a definite item, together with the preparation of specifications for the execution of the work. Also in the portion devoted to designing and calculation, there is no mention of arches, silos, retaining walls, and similar features, and the syllabus implies that a knowledge of the method of calculating the reinforcement for simple floors and roofs only is necessary. In the compulsory subject the candidate is required to possess a knowledge of pressures in silos, bins, and hoppers, but he is apparently not called upon to be able to apply this knowledge in the design of reinforced concrete. Definite mention should also be made of staircase work, and the methods to be followed in the design and execution of pre-cast concrete units.

This portion of the syllabus needs amplification, otherwise the candidate will be misled, unless the examination is a partial one only.

Steel Frame Construction.—The syllabus for this subject is as follows :

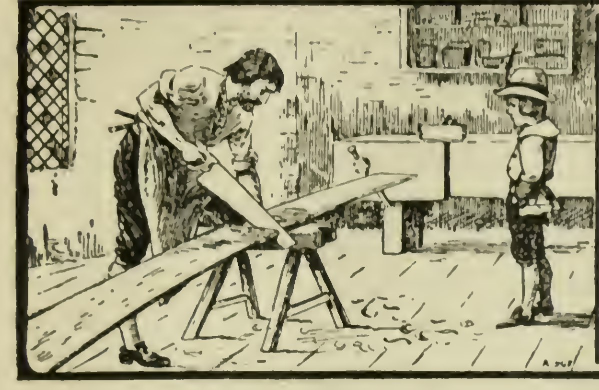
> 10. Steel Frame Construction.
>
> Order of procedure in designing ; external forces, wind, snow, etc. ; arrangement of roofs ; loads on floors ; arrangements of main and cross girders and stanchions ; caps and base plates ; grillages ; junctions ; erection ; brick and stone panels and casings ; protection against fire ; painting ; rough estimates of cost ; rules and regulations.
>
> Candidates desirous of being examined in Masonry, Bridgework, or any other branch of Structural Engineering not specified above may be so examined subject to the approval of the Examination Board and upon notifying the Secretary at least six weeks beforehand.

Here, again, the items are incomplete, and do not cover working drawings or specifications, although rough estimates for cost are specifically mentioned.

Generally speaking, the syllabus for Part 1 of the examination is far more explicit than the second and more important section, and this appears to be inexplicable. There is no doubt that revisions will be made from time to time, in order to bring the subject up-to-date, and eliminate any weaknesses in the syllabus that may become apparent, and it is to be hoped that advantage will be taken of this to include all essential items in the two optional subjects of the second part of the examination.

A note is attached to the syllabus to the effect that candidates may be examined in Masonry, Bridgework, or any other branch of Structural Engineering which is not specified, subject to six weeks' notice being given, and to the approval of the Examination Board.

It will be extremely interesting to see the type of question set in the examination, and it will be of assistance to intending candidates if the papers are published after the examinations are held in order that the standard of qualification necessary can be realised.



A CONCRETE DEVELOPMENT BY THE PORT OF LONDON AUTHORITY.

Among the steadily increasing number of large and important bodies who are applying concrete to an ever-widening field of uses, not the least successful is the Port of London Authority. The Chief Engineer, Mr. C. R. S. Kirkpatrick, M.Inst.C.E., has under construction many interesting and extensive works in both plain and reinforced concrete at the various docks belonging to the Authority. These undertakings are being carried out departmentally under the supervision of Mr. A. Binns, M.Inst.C.E., the resident engineer for the new works.

For general use, a well-equipped yard was established at the Royal Victoria and Albert Docks, where piles, beams, concrete sleepers, and other pre-moulded members are cast and afterwards transported where required. The work at this yard has been going on for two years, and it is remarkable for the enthusiasm with which it is conducted, the large number of experiments that have been carried out, and the originality of the methods employed.

The shortage of timber and other material has suggested the use of concrete for many purposes, a few of which are described among the products mentioned below.

CONCRETE ROAD.

A concrete road now under construction presents many features of interest. The system of reinforcement designed and patented by Mr. J. H. Walker, A.M.Inst.C.E., of the Port Authority, was the outcome of the difficulty foreseen in laying a concrete road upon the particularly soft ground of which the land in the neighbourhood of the Victoria Dock is composed. This system provides for top and bottom layers of reinforcing bars combined and interlocked with zigzag diagonal tension members in such a manner as to form a rigid mattress to which any additional bars may be attached as required. This is shown in *Fig.* 1. One of the advantages of this type of reinforcement would appear to be that it forms a convenient means of putting to good use such old scrap material as wire-ropes, barbed-wire, etc., which can readily be cut to convenient lengths and wired on to the framework where desired.

A novel and interesting combination is a road-laying machine, also designed and patented by Mr. Walker and constructed on the works. This consists of a ½-c. yd. concrete mixer and an electric winch with two drums for operating a skip running along a cable-way so that the material may be deposited with ease and rapidity at the spot required. The cable-way is attached to a framework over which canvas or other suitable material is spread for the protection of the newly laid concrete. The road surface is screeded to finished levels by means of a double-handed screed depending from supports on the framework of the machine in such a manner that the usual wood striking strips are dispensed with and the top wearing surface can be laid on the green concrete of the lower layer. It is of interest to learn that with the small number of men required to work this machine, combined with the fact that the work is carried on practically independently of weather conditions, the labour cost of mixing, laying, and screeding off the concrete is very low. In cold weather the space so enclosed is warmed by means of a fire bucket, and it is a noteworthy fact that a considerable portion of this road was laid in frosty weather with complete success.

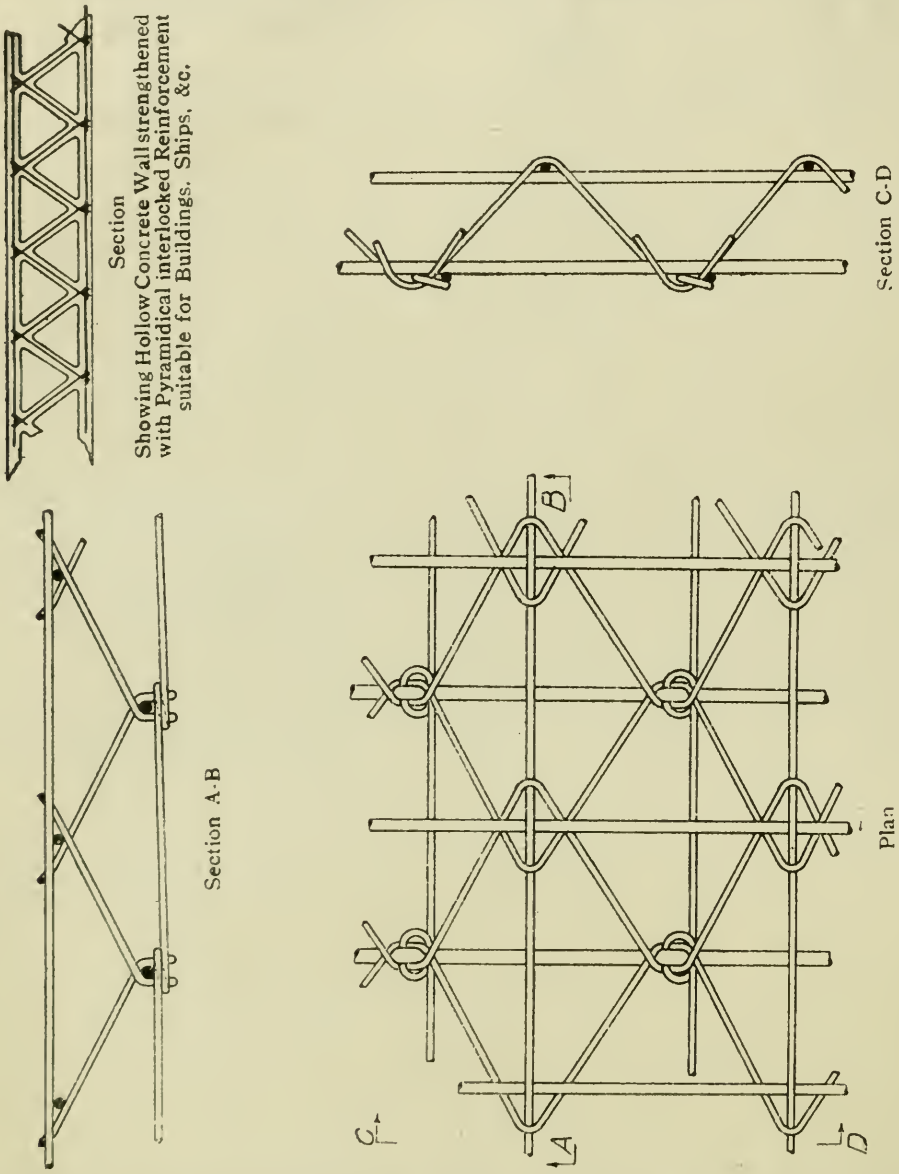

Section
Showing Hollow Concrete Wall strengthened with Pyramidical interlocked Reinforcement suitable for Buildings, Ships, &c.
Section C-D
Section A-B
Plan
A
B
C
D

Fig. 1. Pyramidical interlocked Reinforcement for Roads, Rafts, Floors, Reservoirs, Walls, &c.

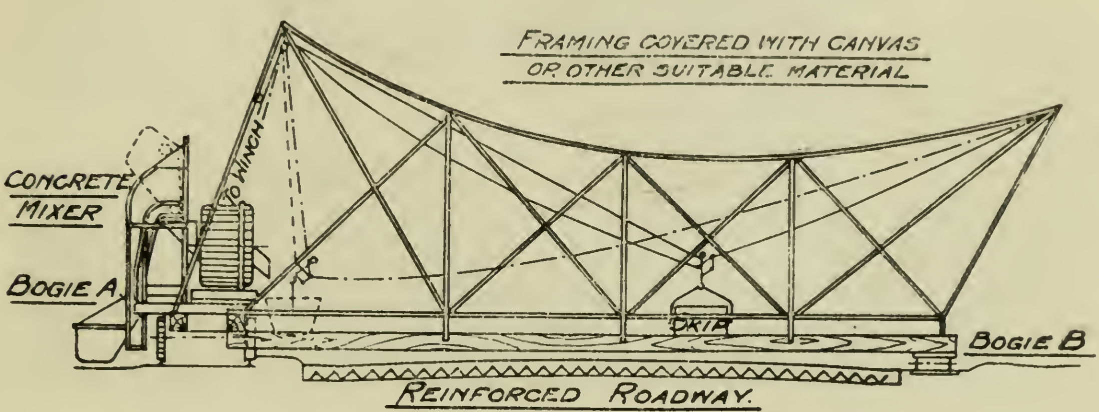
Recent Reinforced Concrete Work at the Port of London Authority.

Fig. 2 is a drawing of the road-laying machine. *Fig.* 3 is a photograph of the roadway with the machine in operation, and *Fig.* 4 shows the framework of the machine covered with canvas.

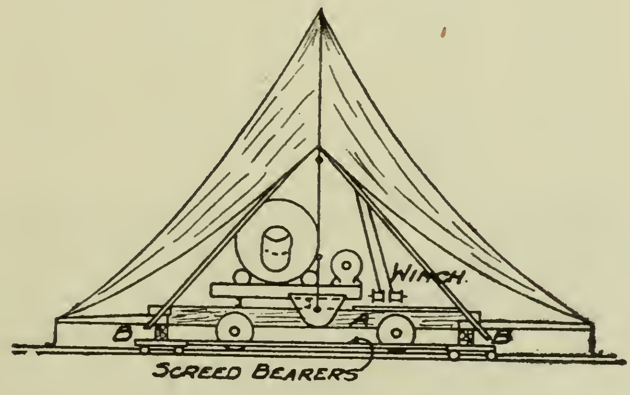
The road is 30 ft. wide between kerbs, and the thickness of the concrete is 9 in., including a surfacing coat of 2 in., the aggregate for which consists of crushed shingle graded from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. and sand, and the proportions adopted are 1 part Portland cement, 1·25 parts sand, and 2·5 parts shingle. Some months after being laid and when the concrete had become thoroughly hard the road was tar sprayed and sprinkled with grit.

CONCRETE SLEEPERS.

The number of experiments carried out in the production of reinforced concrete sleepers has been very large, and various forms are to be seen under trial on the main goods line. These include sleepers of the heavily reinforced kind, 9 ft. by 10 in. by 5 in., and also those of the sleeper block or pad type. Of the former several hundreds are being made for tracks of 7 ft. gauge to carry 5-ton travelling steam cranes of large radius for use at the various dry docks belonging to the Port Authority (see *Fig.* 5). Of the latter only one need be mentioned here, wherein the object desired was to obtain a cheap and easily made block or pad sleeper for ordinary gauge tracks, and at the same time dispense, if possible, with perishable wood or metal ties connecting the pairs of rails or pads. This sleeper, a drawing of which is shown in *Fig.* 6, consists of a pair of blocks to which the rails are attached, separated by an intermediate block lying between them but not attached to them in any way. The special feature



SIDE ELEVATION.



END ELEVATION.

Fig. 2. Sketches of Road-laying Machine for Reinforced Concrete Roads.
RECENT REINFORCED CONCRETE WORK AT THE PORT OF LONDON AUTHORITY.

about the rail blocks is that their bases are inclined downwards towards the centre of the track, as seen in the illustration. By this means it is found that, whereas the tendency of sleeper blocks placed on a level bed is to creep *outwards* on account of the action upon the rails of the wheel flanges, the tendency of these blocks is to creep *inwards* ; this is due to the compensating influence of the inward inclination of the bases, and is met by the intermediate block. No chairs are used, the rails being bolted down to the blocks themselves.

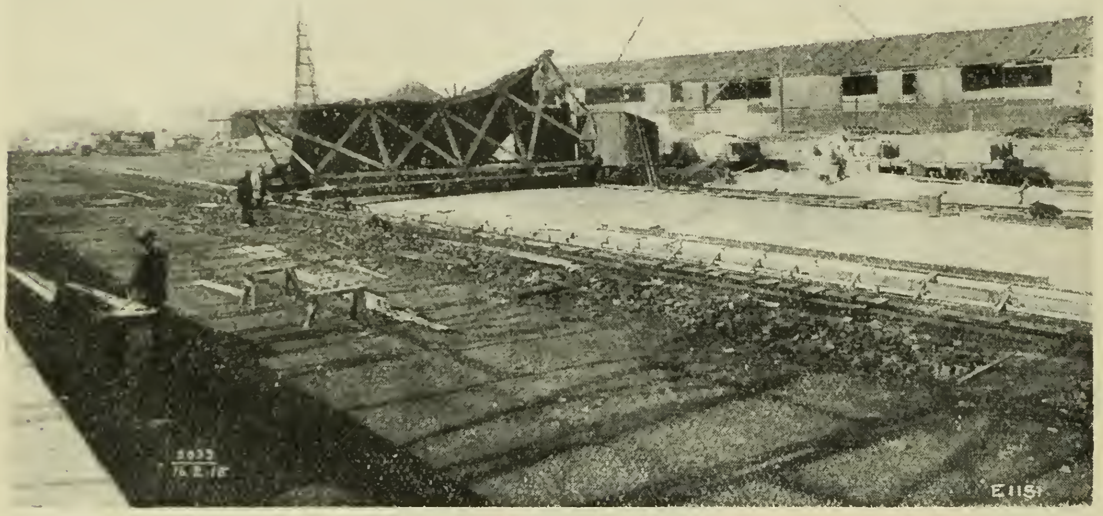


Fig. 3. Reinforced Concrete Road in course of construction, showing the Road-laying Machine.

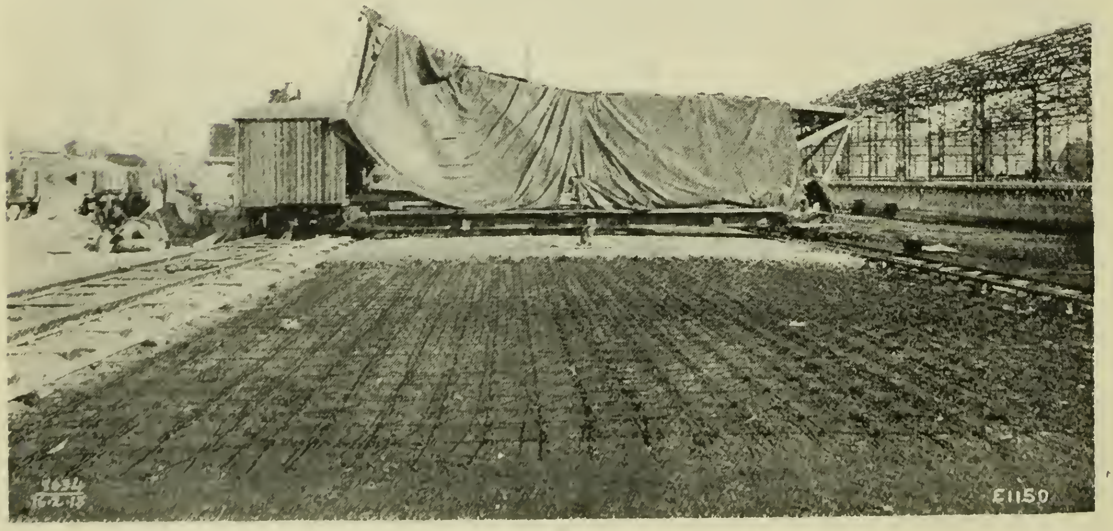


Fig. 4. A Reinforced Concrete Road in course of construction. This photograph shows the reinforcement, and the framework of the Road-laying Machine covered with canvas.

Recent Reinforced Concrete Work at the Port of London Authority.

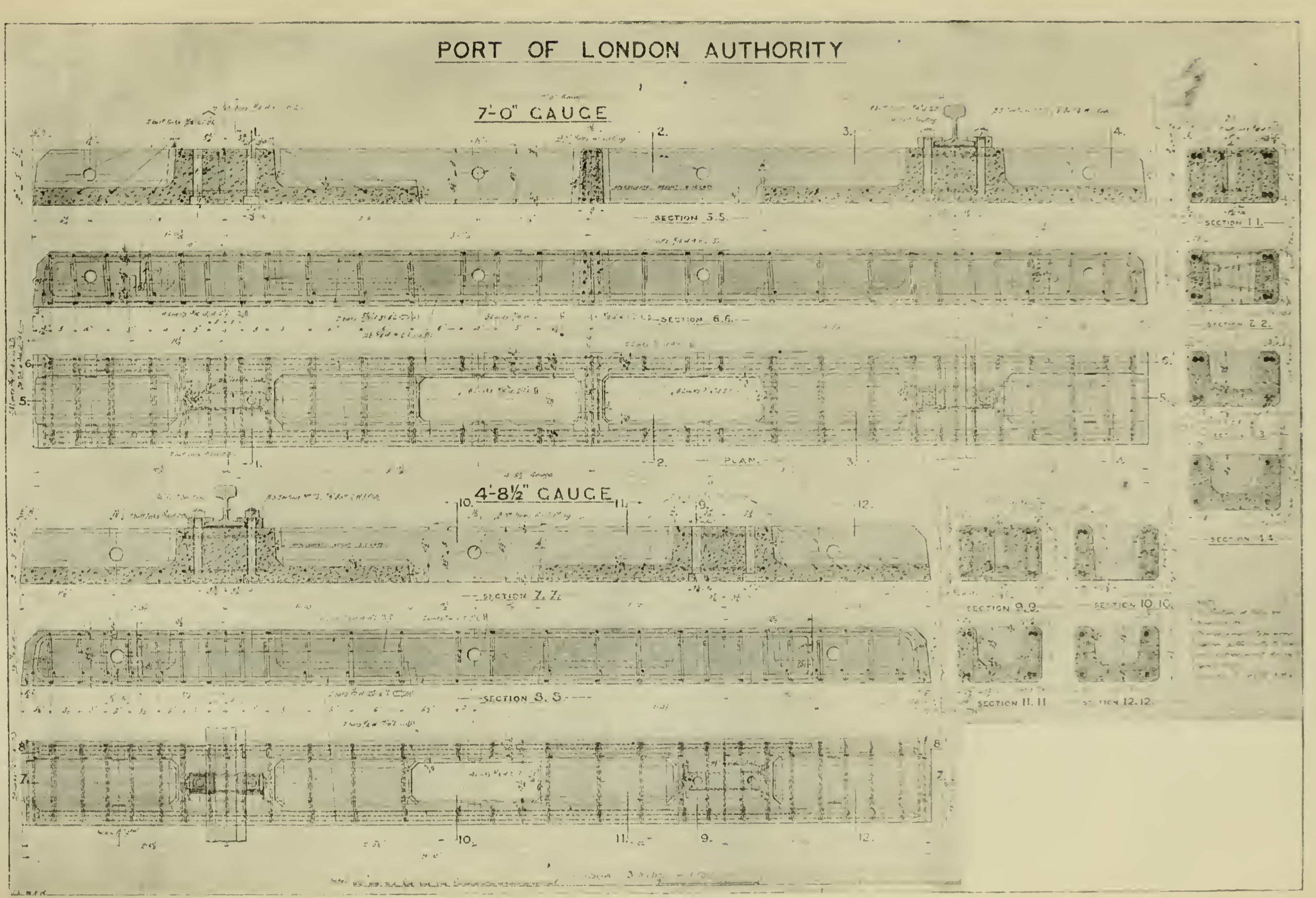


Fig. 5. Concrete Sleepers for use on tracks of 7 ft. gauge to carry 5-ton Travelling Steam Cranes

RECENT REINFORCED CONCRETE WORK AT THE PORT OF LONDON AUTHORITY.

These sleepers have been in use on the main goods line for over a year, and are perfectly satisfactory. As a result of the experience thus acquired it is considered that the intermediate block is only necessary at intervals, say, between every fourth or fifth pair of rail blocks.

The test which these sleepers is undergoing is all the more severe in that they are laid in the curved track upon a recently widened embankment, where the ballast consists of the ash filling of which the bank is composed.

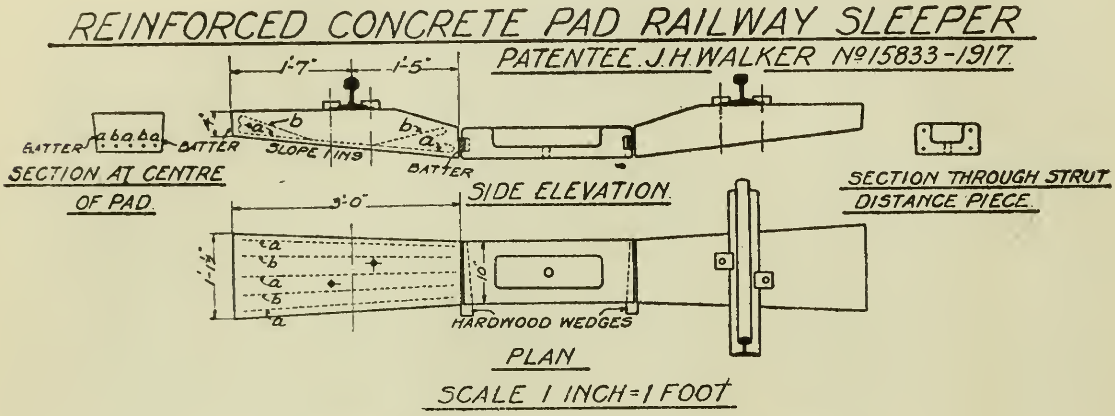

REINFORCED CONCRETE PAD RAILWAY SLEEPER
PATENTEE. J.H. WALKER No. 15833-1917.
1'-7"
1'-5"
BATTER
BATTER
SLOPE LINS
BATTER
SECTION AT CENTRE OF PAD.
SIDE ELEVATION.
SECTION THROUGH STRUT DISTANCE PIECE.
3'-0"
1'-1½"
10"
HARDWOOD WEDGES
PLAN
SCALE 1 INCH=1 FOOT

Fig. 6. Reinforced Concrete Pad Railway Sleeper.

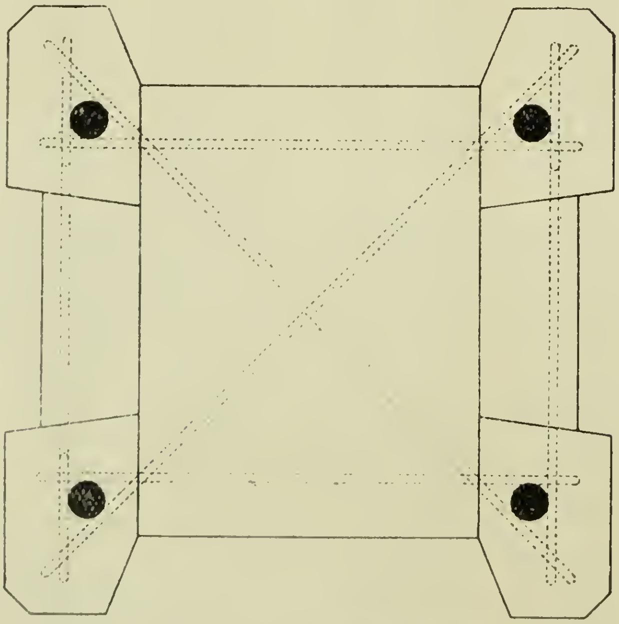


Fig. 7. Sectional Detail of Reinforced Concrete Telegraph Pole.
Recent Reinforced Concrete Work at the Port of London Authority.

TELEGRAPH POLES.

These, which are of a new pattern, are being constructed 36 ft. in height, untapered, perforated, and 12½ in. square in section. The reinforcement is an adaptation of that used for the road. *Fig.* 7 shows the sectional details of a pole, and *Fig.* 8 the elevation, while *Fig.* 9 is a photographic view. The oblong

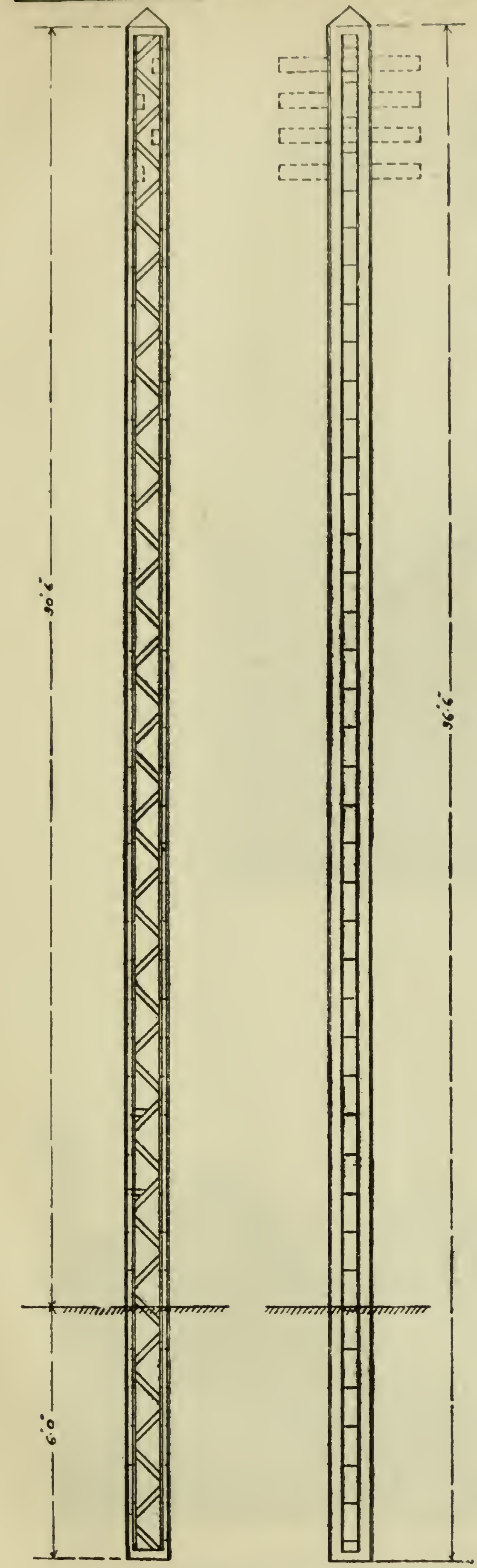


Fig. 8. Details of Telegraph Poles.
RECENT REINFORCED CONCRETE WORK AT THE PORT OF LONDON AUTHORITY.

holes in the sides of the pole make it easily climbable. Poles of a greater height will be tapered from the base upwards.

PILES.

These are being made in large numbers, from tapered bearing piles 18 ft. long to parallel heavily reinforced piles 56 ft. long of square section.

FENCING POSTS.

These, again, constitute a novelty, being hollow, circular in section, and slightly tapered, having a diameter of 6 in. at the base, with concrete 1¼ in. thick. They are cast vertically and upside down, and the moulds are provided with an ingeniously devised core operated on the principle of the boot-tree, so that when the middle section is withdrawn the two side pieces collapse, and may be easily removed from the mould.

These posts are not intended for wire-fencing, but, being close together with about one-inch spaces between them at the bottom and tied together at the top by a perforated concrete member which slips over the top of the posts, they form an unclimbable fence 9 ft. high, of the type known in connection with docks as a "customs" fence. See *Fig.* 10.

WALLS.

The interlocked reinforcement used horizontally in the roads and in foundations is also used vertically in platform and retaining walls and in the walls of buildings. In the latter adaptation a large shed, carried on a reinforced raft, is being constructed for the storage of grain. The walls have an additional interest in the fact that instead of being solid they are of the hollow-wall type. A cross-section of a wall in plan consists of an inner and outer skin connected together by concrete diagonal members similarly to the front elevation of the telegraph pole in *Fig.* 8. This is also seen in *Fig.* 1.

The reinforcement is designed to give vertical and horizontal strength to the

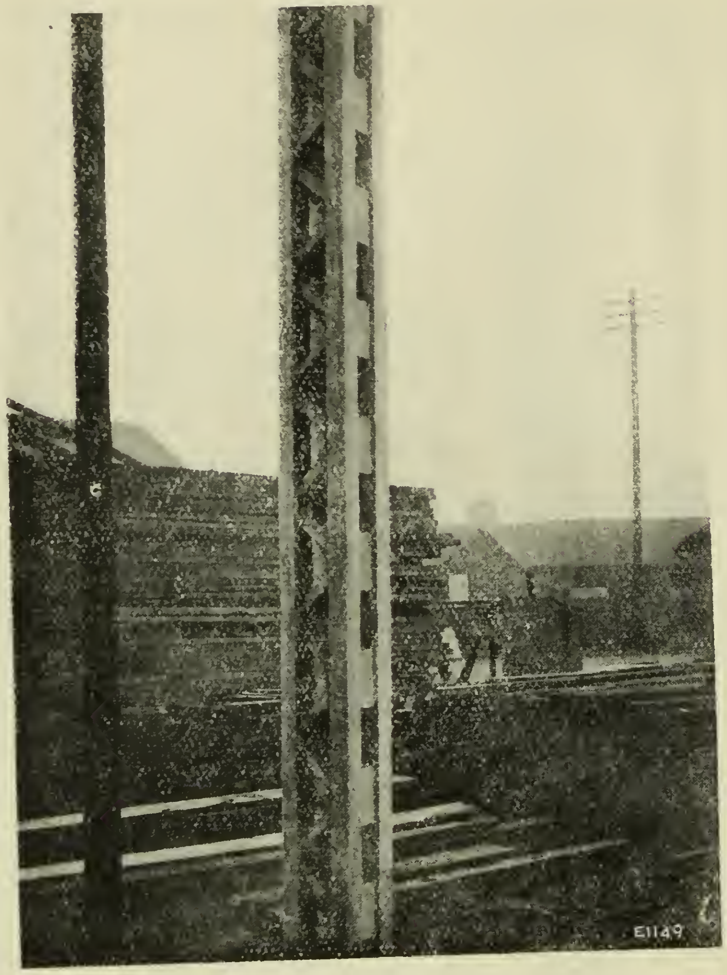


Fig. 9. Reinforced Concrete Telegraph Poles.

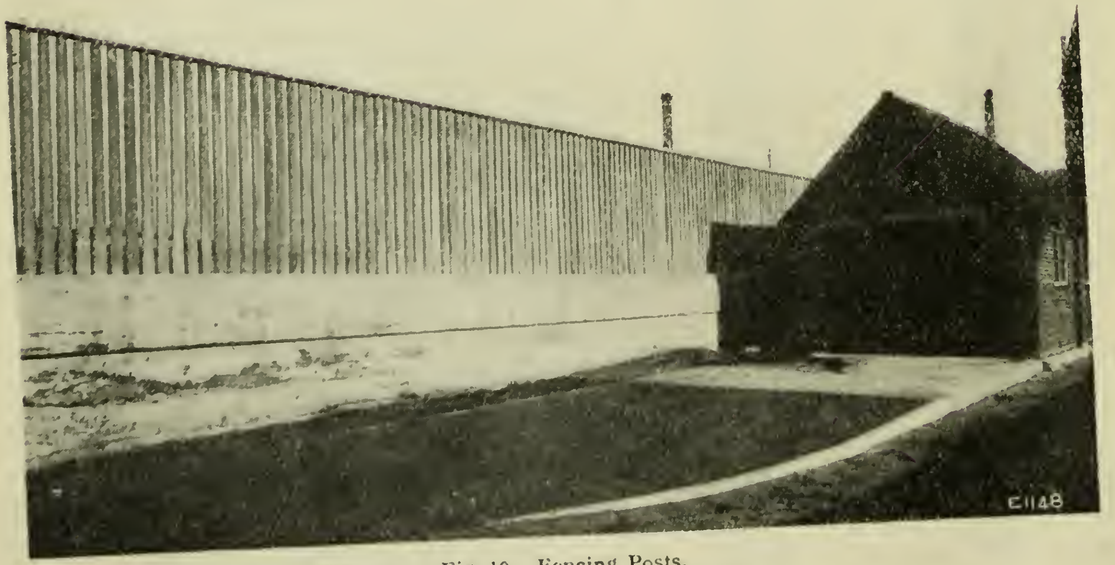


Fig. 10. Fencing Posts.

Recent Reinforced Concrete Work at the Port of London Authority.

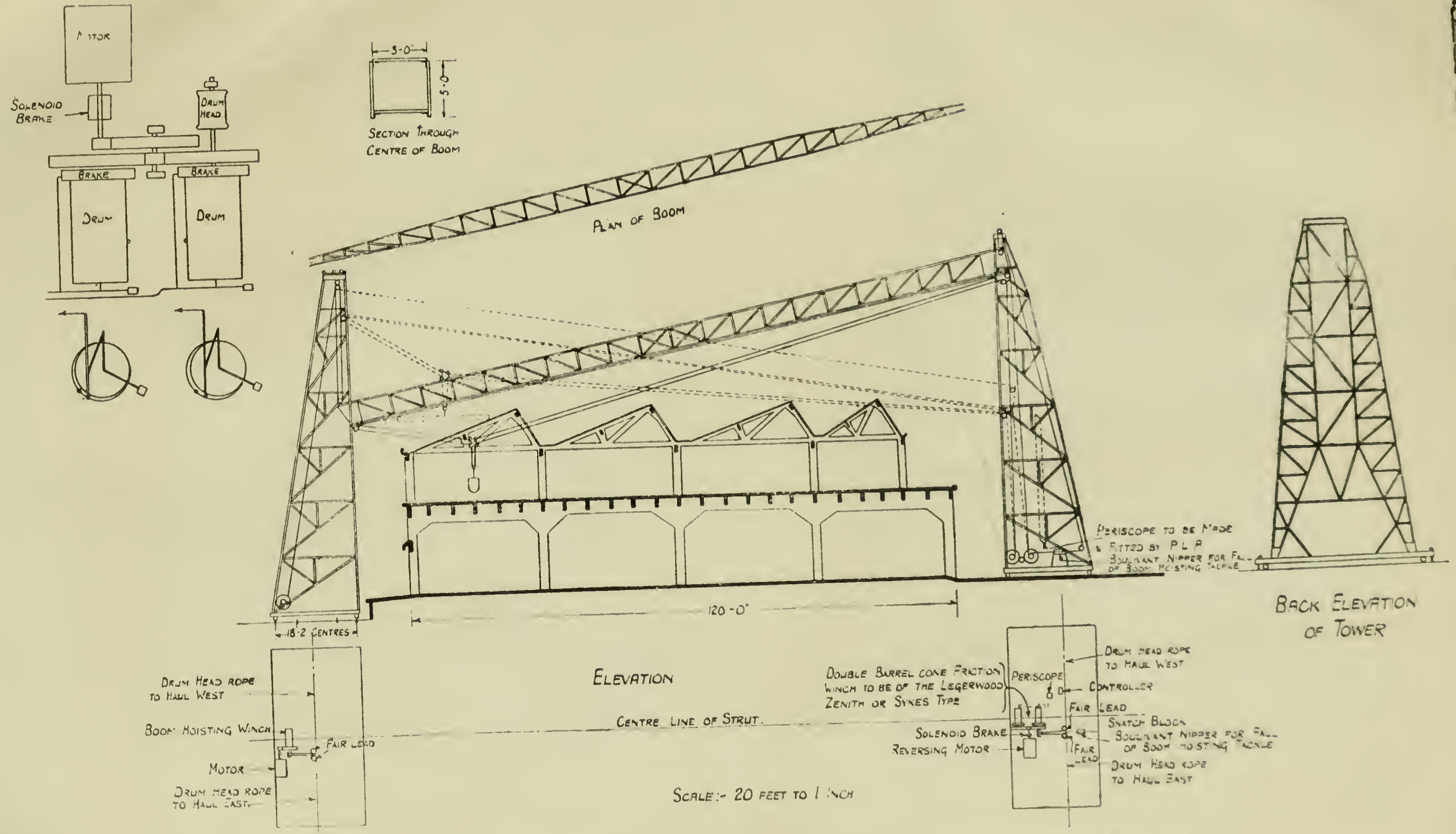

MOTOR
SOLENOID BRAKE
DRUM HEAD
BRAKE
BRAKE
DRUM
DRUM
3-0"
5-0"
SECTION THROUGH CENTRE OF BOOM
PLAN OF BOOM
PERISCOPE TO BE MADE & FITTED BY P L A
BOULANT NIPPER FOR FALL OF BOOM HOISTING TACKLE
BACK ELEVATION OF TOWER
18'-2 CENTRES
120-0"
ELEVATION
CENTRE LINE OF STRUT
DRUM HEAD ROPE TO HAUL WEST
BOOM HOISTING WINCH
FAIR LEAD
MOTOR
DRUM HEAD ROPE TO HAUL EAST
DOUBLE BARREL CONE FRICTION WINCH TO BE OF THE LEGERWOOD ZENITH OR SYKES TYPE
PERISCOPE
DRUM HEAD ROPE TO HAUL WEST
CONTROLLER
FAIR LEAD
SNATCH BLOCK
SOLENOID BRAKE
BOULANT NIPPER FOR FALL OF BOOM HOISTING TACKLE
REVERSING MOTOR
FAIR LEAD
DRUM HEAD ROPE TO HAUL EAST
SCALE:- 20 FEET TO 1 INCH

Fig 11. Cableway Overhead Strut Appliance for Construction of Double-Storied Concrete Sheds.
Recent Reinforced Concrete Work at the Port of London Authority.

walls in order to resist the pressure of the stacked grain, and the walls are cored to reduce their dead weight whilst increasing their width, and also to minimise internal condensation of moisture on the inner face of the wall.

For use on large work, such as two-storey sheds, Mr. Walker has designed a travelling electrically-operated overhead cable-way crane by means of which the material can be deposited at any desired position. A drawing of this crane, which is designed for 3-ton loads and is now being constructed, is seen in *Fig.* 11. The span is 140 ft., and the cable-way is attached to the underside of a light overhead girder, which is supported by block and tackle at each end from the top of two traversing towers, and is inclined in either direction as required.

The girder gives the necessary resistance to the pulls of the cable-way rope, and is designed in light sections of a sufficient strength to carry its own weight. The action of gravity on the girder tends to sag it downwards in the middle of its span, whereas the pulls of the loaded cable-way rope exert an upward buckling effect on the girder, and thus one bending moment neutralises the other.

A description of the larger work, such as cold storage buildings, dry docks, etc., does not come within the scope of these notes, but sufficient has been said to indicate the direction which the newer applications of concrete have taken and the rapid advance which has been made.

REPORT OF THE SPECIAL COMMITTEE OF THE CONCRETE INSTITUTE ON RELATIONS BETWEEN ARCHITECTS AND SPECIALIST ENGINEERS.

The following report is taken from the Presidential Address delivered by Mr. H. D. Searles-Wood at the opening meeting of 1918-19 Session of the Concrete Institute in November.—ED.

On November 18th, 1915, the Council of the Concrete Institute appointed the following as a Special Committee to consider and report upon the Relations of the Architect, the Reinforced Concrete Specialist and the Structural Engineer :—

Professor Henry Adams, President, M.Inst.C.E. ; Dr. Oscar Faber, D.Sc. (Chief Engineer of Messrs. George Trollope & Sons and Colls & Sons, Ltd.) ; Mr. H. D. Searles-Wood, F.R.I.B.A. ; Mr. T. B. Shore, Manager of Considère Construction Co , Ltd. ; Sir Henry Tanner, C.B. ; Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E. (Engineer to Indented Bar and Concrete Engineering Co., Ltd.) ; Mr H. Kempton Dyson (Hon. Secretary of Committee).

The Committee held meetings on January 6th, February 24th, April 13th, April 18th, and June 15th, 1916.

Sir Henry Tanner was elected by the Committee to act as Chairman.

The increase in scientific knowledge in the nineteenth and present centuries has not left unaffected the construction of modern buildings, and at present there are very few buildings in which concrete and steel do not form important parts of the whole.

The calculations and detail designs for such structural elements necessitate the exercise of specialised engineering knowledge and involve considerable additional work beyond the duties of the architect. It is usual, therefore, to employ an engineer to design the structural steel or reinforced concrete portions of the buildings.

The employment of an engineer to design such details of construction does not mean that the architect's work is reduced in any way. Indeed, the architect has now more duties to perform than in the past, owing to the more complicated nature of buildings generally, involving the co-ordination of various specialist trades. Not only has he to prepare and direct the general scheme of building operations, to plan the buildings, design the æsthetic features and prepare the ordinary constructional details and specifications, but he has to see that the many by-laws and regulations are conformed to. These latter increase in number, while the law of building contracts in itself is becoming more intricate as time goes on, and the architect is generally required to occupy the position of a quasi-arbitrator between client and contractor.

The functions of the architect have changed with the progress of civilisation, and there are some differences in practice in different countries. In the Middle Ages the designer and general superintendent of building operations was a master craftsman, employing labour direct. This still applies somewhat to-day in France and Germany and in the Colonies. Within modern times in England the architect acted as contractor, tendering in competition, even for large public buildings, by submitting a design and price at one and the same time. We still have contractors, prepared to submit designs for buildings complete with their price, but the practice is not generally considered to be satisfactory by clients, who wish to have their interests watched by one whose interests are entirely independent. The practice of architecture has thus become exclusively professional. In an allied way the practice of civil engineering has also become professional.

Originally the contractor had to take out his own quantities from the architect's or civil engineer's drawings, in order to prepare his price, and with a multiplication of competing contractors this meant considerable waste in duplication. In order to save this the profession of quantity surveying came into being. Seeing that the preparation of the bills of quantities is incidental to the contractor's pricing of the work and to the adjustment of variations and extras, the quantity surveyor's fees are part of the cost of construction, and are customarily included in the bills of quantities for payment out of the contract sum, although in some cases the surveyor is paid direct by the client.

Other innovations in building practice have been the invention of fire-resisting construction, heating and ventilating apparatus, sanitary appliances, hydraulic and electric lifts and other mechanical plant. These features, which all require special design, were at first, and are still, largely supplied by inventors, acting as manufacturers and sub-contractors, and are often selected by architects and included in the bills of quantities for payment out of the contract sum. With increasing knowledge architects have occasionally prepared the designs for such details, when they were quite simple, and have asked nothing for the extra work, whilst in other cases the manufacture of special fittings has become somewhat standardised, so that the cost of the design forms but a small proportion of the manufacturer's establishment charges.

In structural engineering each job is individual and there is little repetition. The cost of the designs for the details of reinforced concrete or structural steel work is therefore considerable; and when this work is multiplied, by several specialist engineers submitting competitive designs, the costs are largely increased and have finally to be met by the client in the form of increased charges, included in the tenders. Some specialist firms obtain their fees for design by way of profit on the steel work, which they sell; some again by selling patented forms of steel bars, others by sub-contracting for the whole work of manufacture and construction, and still others by charging royalties or fees, which are paid by the general contractor and included in his tender.

Competition in design and price has at the same time led to abuse, not only in respect to extravagance by duplication of work, or in the difficulty of securing the client's interests, in adjusting variations and extras, but in respect to the encouragement which such a system gives to skinning and scamping in design and execution. It pays competing firms to take risks. The conscientious designer is at a disadvantage, and therefore the unscrupulous are often encouraged at the expense of those who are doing their best to supply what will efficiently meet the client's requirements. Yet the architect is called upon to bear the onus of failure; for he cannot evade legal liability for the design and supervision of such structural work unless the designer of such details has professional status properly recognised by the building owner. Time is generally saved by the collaboration of the specialist engineer with the architect in the initial stages, which in itself makes for economy.

The following paragraphs from the American Institute of Architects' Memorandum on the professional practice of architects and schedule of minimum charges are worthy of note :—

" The architect's professional services consist of the necessary conference, the preparation of preliminary studies, working drawings, specifications, large-scale and full-size detail drawings, and of the general direction and supervision of the work, for which (except as hereinafter mentioned) the minimum charge, based upon the total cost of the work complete, is 6 per cent.

" The architect is entitled to compensation for articles purchased under his direction, even though not designed by him.

" Where heating, ventilating, mechanical, structural, electrical and sanitary problems are of such a nature as to require the services of a specialist the owner is to pay for such services. Chemical and mechanical tests and surveys, when required, are to be paid for by the owner."

The Committee considers that, when an architect desires to employ an engineer to design and supervise the erection of reinforced concrete or steel frame construction, the client should pay an additional percentage on that portion of the work.

The rate of payment should be varied according to the amount of work entailed in the structural engineering design, specification and supervision; but, as a general indication, it is suggested that the additional fee to the specialist engineer should consist of a commission on the cost of the particular details which he designs It is emphasised that the engineer's fees would only be charged on a portion of the work, rarely amounting to a third of the whole cost of the building.

As regards the supervision which is to be required from the structural engineer, it should be distinctly understood, as in the case of the architect, that such supervision is different from the continuous personal superintendence which may be secured by the employment of a clerk of works or superintendent of construction. The supervision by the engineer means such inspection (by himself or deputy) of work in process of erection, completion or alteration, or of work in shops, as he may find necessary to ascertain whether it is being executed in general conformity with his drawings and specifications or directions.

A clerk of works or superintendent of construction will generally be required, and such assistance should be employed by the architect at the owner's expense, the responsibility of the engineer being protected at the same time by the latter being empowered to require the discharge of the clerk of works or superintendent if he considers his work inefficient. Reinforced concrete in particular requires continuous attention from superintendents of special training and experience, and it may be necessary on works of magnitude to engage more than one clerk of works or superintendent to protect adequately the interests of the owner.

The Committee is of opinion that the rational procedure would be for the architect to select a specialist engineer, who should design the structural engineering work in consultation with him, and then to have bills of quantities of the special work prepared by the surveyor engaged for the remainder of the work, so that all can be issued together. By this means fair tendering would be obtained and any variations could be properly priced. The architect's commission has hitherto covered all the necessary services in the designing of a building, and it seems, therefore, that in some way this course should be continued, especially having regard to the architect's responsibility for the whole structure; because otherwise he would have difficulty in recovering from the engineer, as there would be no privity of contract. The Committee suggests, therefore, that the remuneration of the architect should take the form of some addition to the usual percentage, according to the character of the work—say, 20 per cent. to 25 per cent.—wherever skeleton steel or reinforced concrete structures are used; and it has to be borne in mind that by the employment of an engineer the architect derives *some* saving in labour and expenses, but by the above suggestion practically the *whole* cost would be met.

It is not the province of the Committee to suggest what the remuneration of an architect should be, but it would seem that no single percentage can meet all cases, consequently its recommendation is for a percentage in regard to engineering works on the charge that would otherwise be made on the whole work.

I regret that the Royal Institute of British Architects has decided not to deal with this Report.

With regard to the specialist, there are several kinds: he may, for instance, deal in a patent article requiring special knowledge for its application to individual cases, such as some reinforced concrete systems. Again, the specialist may be the contractor, his services consisting not only of design but of execution, and here again special knowledge has to be adapted to individual cases; in this connection take the cases of heating and lighting systems. A third instance is a specialist product, such as elevators and labour-saving devices of the like nature. Again, there is the specialisation in a material, probably requiring expert chemical knowledge, such as waterproofing compounds, special pavings, etc. There is also the specialist who assists the architect in his work at a fee, as for instance the quantity surveyor or the constructional steelwork designer. There are varying degrees in each case, and it is impossible to draw a line between the various types involved; with regard to the work now commonly undertaken by specialists there is a broad line of distinction to be drawn between the following classes:—

(1) Work forming an integral and essential part of the structure, such as steel framework, or, in a stronger degree, reinforced concrete construction.

(2) Work which is, to a greater or lesser degree, applied to or installed in the finished structure, such as heating, ventilating and lighting systems, power installations, etc., and equipment generally.

With regard to the former, the architect's services in organising such matters are very onerous, and all architects cannot have detailed knowledge of all the work comprised in the second class, although many may have specialised in certain branches of each class in addition to their general architectural knowledge.

With regard to the first class, such work is a modern development of building construction and is so essentially a matter for an architect's personal attention, that his knowledge should be much more than superficial, and he should have given such matters as much study as if he proposed actually to undertake the work. The architect in these days must be a capable organiser, but there must be no danger of his degenerating into an organiser solely.

It is specialist work of the first class, that the Concrete Institute is strongly of opinion should not be the subject of competition in design ; and I would urge it for the further reason that inefficient design in constructional work can scarcely be detected until after the building is handed over or when an actual case of failure occurs ; and even if it is discovered by testing or otherwise, the defect cannot be remedied without great expenditure and loss to one or more of the contracting parties. A failure will in any event cause extreme inconvenience and almost certain damage to the client and possibly bring discredit upon the architect.

It is not sufficient for an architect to safeguard his client by merely drawing up agreements, etc. ; he should be able to, and should actually, satisfy himself that the specialist's work is, in the circumstances, in every way suitable.

It is not possible to draw up a form of appointment for the specialist which is applicable to all the varying conditions under which he is employed, but the following points should be borne in mind as to his duties :—

(1) He should prepare all plans, calculations, instructions and quantities necessary in the opinion of the architect, and these particulars should be sufficient and adequate, and should be based on the architect's instructions.

(2) He should be responsible for the accuracy and efficiency of his designs, and for the strength and efficiency of the work carried out to his designs.

(3) He should carry out his work with due diligence.

(4) He should obtain the architect's approval for the whole of his work, such approval not to relieve him of his responsibility.

(5) He should be cognisant of and comply in all respects with the requirements and regulations of local authorities and other bodies under whose jurisdiction the work is to be carried out.

(6) He should undertake not to divulge any particulars or information furnished by the architect, or to publish particulars of the work in the Press or otherwise, without the express sanction of the architect.

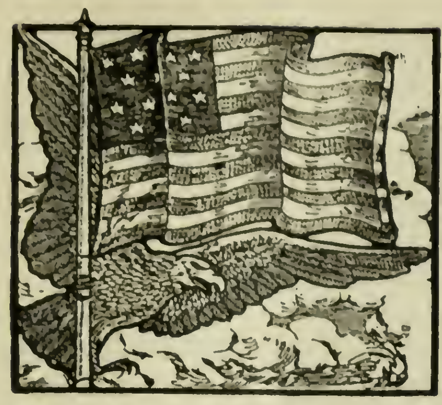
(7) He should relieve the client and the architect from responsibility and cost in connection with the infringement of patents, and he should accept all liability in connection with the work executed to his designs.

(8) He should be prepared to visit the work during progress and after completion, and to make all necessary tests and give written reports from time to time as the architect may require as to the manner in which the work is being carried out.

On the subject of the second class, namely, specialist's work applied to or installed in the finished structures :—

There is great need for more intimate working between the architect and specialist so that the building is best adapted for the machinery or fittings installed. Speaking as an architect, I have found great difficulty in getting mechanical engineers to decide where they want to place their shafting and machinery, and I have often had to stop them cutting through essential structural members in the building. I suppose the chief reason is that not sufficient time is given to the consideration of these things before the building is started.

The point that I wish to make is that, in all these matters, the sooner the architect can come in touch with these specialists and agree on the way in which the various schemes are to be carried out, the better the building will be adapted to contain them and the smoother the carrying out of the work will be made.



THE NEW REINFORCED CONCRETE BUILDINGS FOR THE WAR AND NAVY DEPARTMENTS, WASHINGTON, D.C.

(Contributed.)

For the following interesting particulars and illustrations we are indebted to the Bureau of Yards and Docks, Navy Department, Washington.—ED.

Overcrowding of Government departments at Washington with work and workers upon the entry of America into the war necessitated an abnormal expansion in office accommodations. Resort has been had to every known housing expedient—rentals, commandeering of finished and unfinished structures, remodelling, and " emergency " construction.

The War and Navy departments, of all governmental functions, naturally experienced the greatest increase in technical and clerical staff. The former, confronted almost immediately by a tenfold increase, early embarked on the adventure of temporary frame and pebble-dash construction. All available vacant tracts in central Washington were soon covered with buildings of this type. The municipal tennis grounds no longer exist as such. Park development programmes long years in formulation were perforce laid aside. Within a stone's throw of the capital now stands a group of three office buildings, probably the largest operation of its kind ever undertaken—containing more than a million sq. ft. of floor space. Of frame-and-stucco construction and three stories in height, this group had its beginning on October 11th, 1917 ; first occupancy early in January, 1918 ; completion and full occupancy by the middle of February following. It houses important bureaus with a staff of 10,000 employees, but, even at this, it represents only a fraction of the War Department's building effort in Washington.

The Navy Department's problem was not quite so instant in urgency. No new functions have had to be added to its organisation, and its expansion, while great, had been perhaps more gradual. Only a minimum amount of wood construction has at any time been undertaken for its offices. For more than a year of the war accommodations were found for its bureaus in its original quarters or rented space in various parts of the city. Meanwhile, careful study was devoted to the situation as it developed, and all possible expedients analysed. Finally a bold solution, now realised, was suggested.

Efficiency demanded the location of the entire Navy Department under a single roof, and its important activities and documents required accommodations more nearly fire-resisting than wooden construction could afford. Speed in erection was essential, but an indefinite term of occupancy of the completed structure was contemplated, while high unit-costs were forbidden.

The use of reinforced concrete seemed to meet the foregoing conditions most fully. Experience with this material by the Bureau of Yards and Docks (which is charged with the construction of all naval works ashore) had been extensive and very fortunate during the war period, and its officers were able to make a very clear case for concrete in the project under consideration. Investigation revealed that, while an office-building larger than any previously erected for such purposes was required, it could be built of concrete with great rapidity, and at a cost not unreasonably above that of an equivalent frame structure. The interest of a construction company of proved resources was enlisted, assuring the requisite labour and skill. Regular and speedy delivery of materials had already been placed within the Government's command.

Presented with such data, the House of Representatives was prevailed upon to make an appropriation for the building designated, on the basis of $3 per sq. ft. On the same terms, the House saw fit to provide additional quarters of almost equal magnitude required by the War Department. The bill embodying this appropriation did not become a law until March 28th, 1918, but the urgency of the situation prompted the signing of the contract and the beginning of work on the site on February 25th, assurance having been obtained from responsible sources that the project would suffer no impediment in the Senate.

The group as it now stands, though divided into two parts by a 100-ft. roadway, represents essentially a single operation. As such, it affords a greater area of office space than any similar undertaking in existence, with 1,800,000 sq. ft. of floor, or about 41 acres. Its nearest rival in this respect is the Equitable Building in New York, with 1,700,000 sq. ft. in its 41 stories.

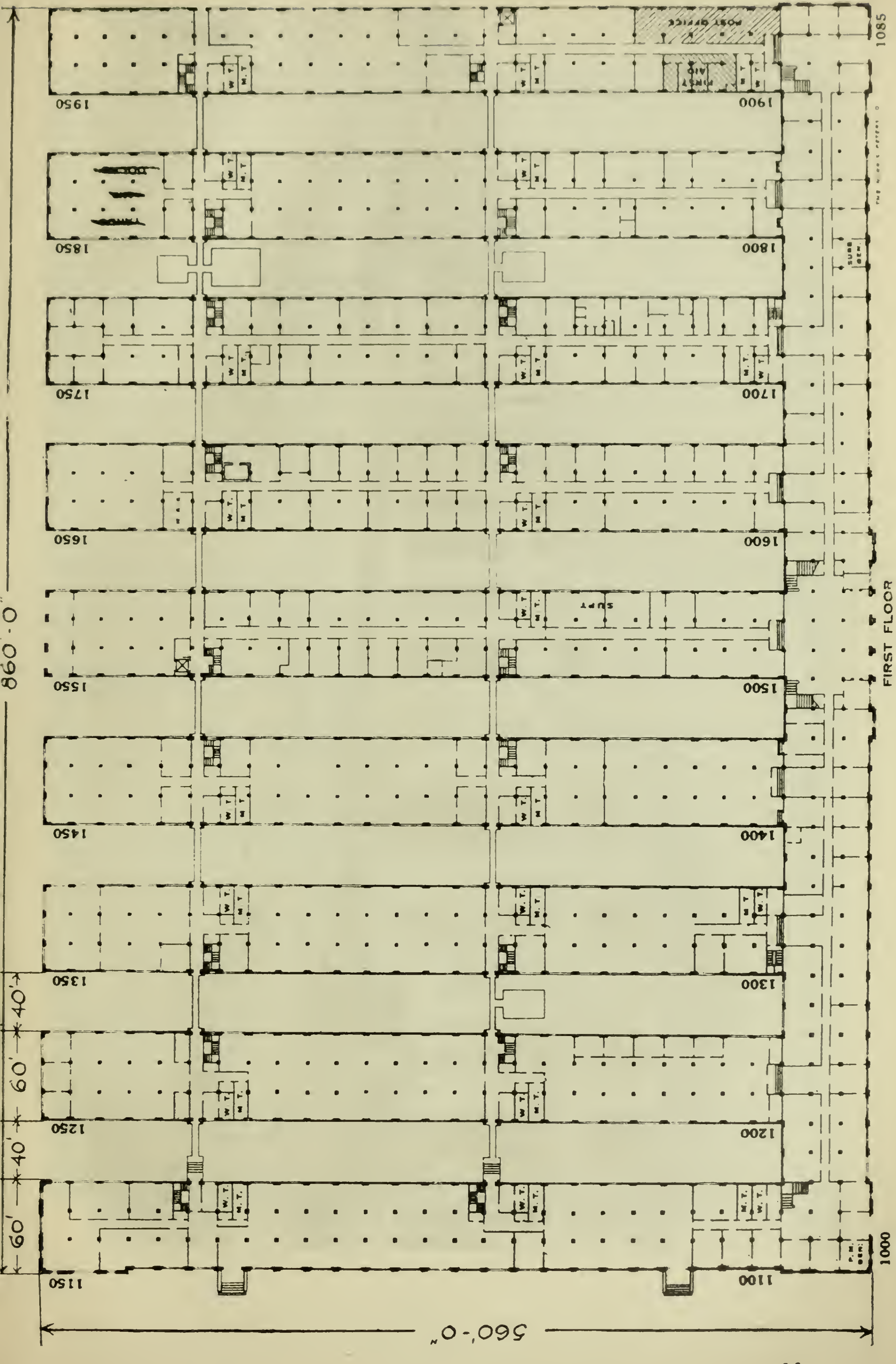
Occupation of the Navy Department and War Department buildings began on August 17th and August 31st, 1918, respectively; occupation of both was complete early in October. Five and a half months was the time from the date of signing the contract until beneficial occupancy of this prodigious group was obtained. Fourteen thousand employees are now transacting business within its walls.

DESIGN.

Plans and specifications for the project were prepared by the Bureau of Yards and Docks, who likewise supervised the erection.

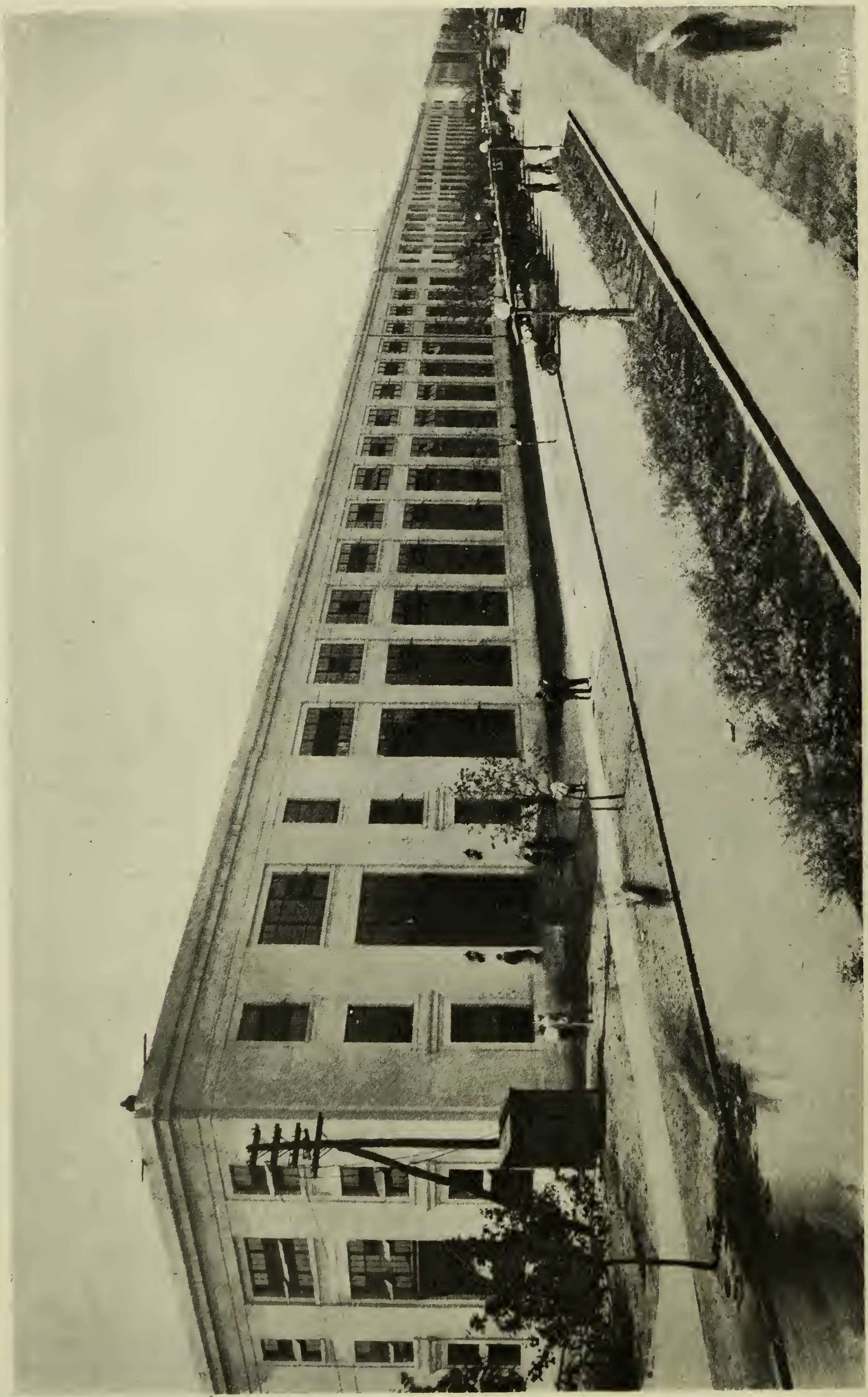
The buildings are three stories in height, with a structural framework of reinforced concrete, gypsum-board and plaster partitions, steel sash, and brick curtain walls. The latter are omitted along the exposed front and side façades, where a two-storied window treatment is used, and the concrete surface finished with a white cement-and-sand mixture rubbed in by hand.

The plan of each building is simple, consisting of parallel wings 500 ft. long and 60 ft. wide, connected at the front by a so-called "headhouse" 60 ft. in width. The Navy Department unit has nine such wings, the War Department eight; this is their only difference in plan or treatment. The wings are separated from one another by courts 40 ft. wide, each of which is crossed by two covered gangways at the level of the second floor. The ground occupied, inclusive of courts and driveways, is about 20 acres in area.



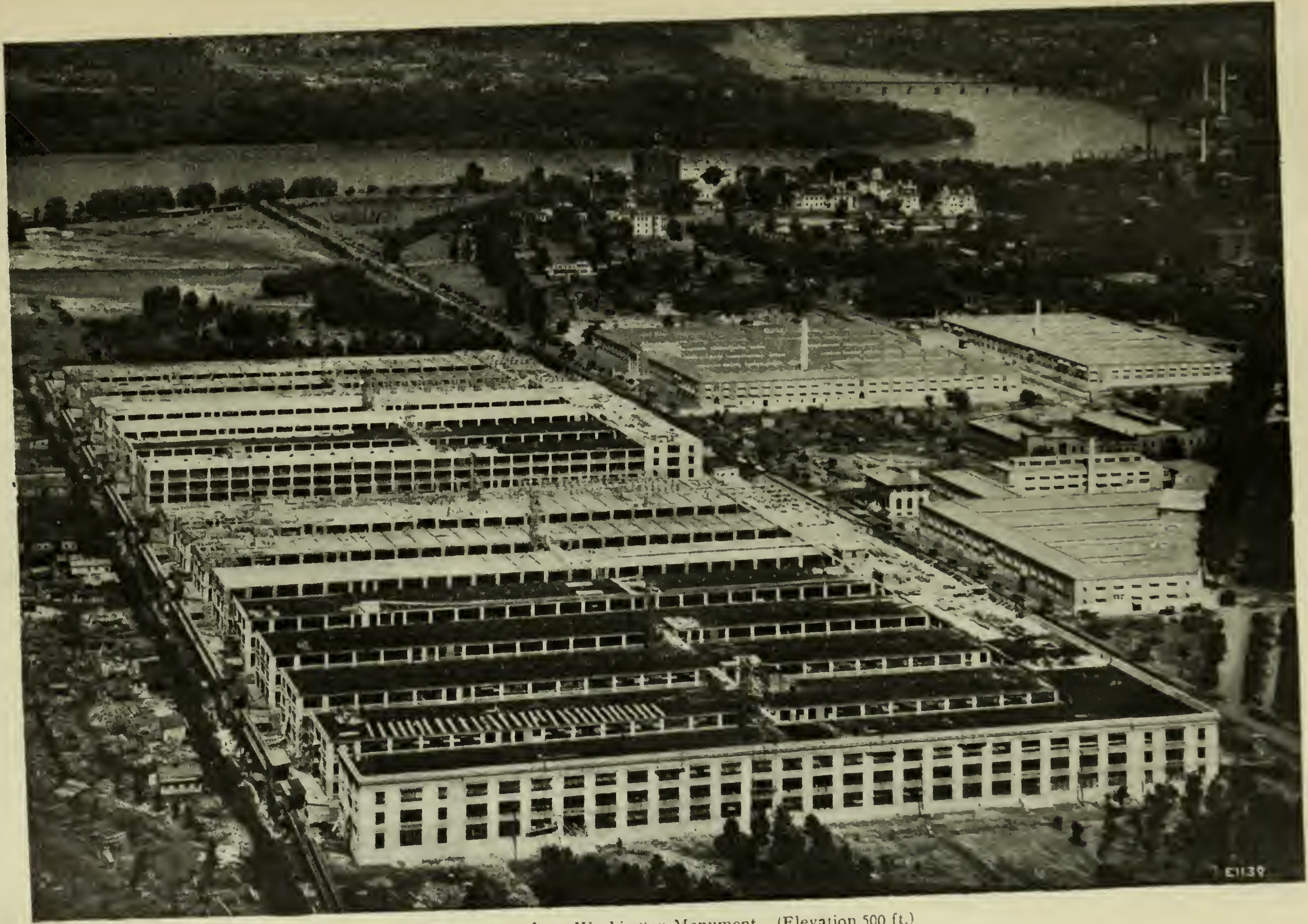
Typical Floor Plan.

New Reinforced Concrete Buildings for the War and Navy Departments, Washington, D.C.



North (Front) Facade.

New Reinforced Concrete Buildings for the War and Navy Departments, Washington, D.C.
Navy Building in Foreground.



View looking from Washington Monument. (Elevation 500 ft.)

New Reinforced Concrete Buildings for War and Navy Departments Washington D.C

Speedy erection demanded that the structural design be of the simplest type, and the beam and girder system was selected. This treatment resulted in a scheme of uniform structural units throughout, all column-spacing and distances between girders being similar without exception, and complicated connections of beams and girders at columns being precluded.

As will be seen in the accompanying illustrations, the two buildings are identical in appearance, the front and side façades being divided by pilasters into bays.

All floors are of reinforced concrete, designed to support a live load of 75 lb. per sq. ft., and are finished with a wearing surface of concrete. They are $3\frac{1}{2}$ in. thick, with one-way reinforcement of $\frac{3}{8}$-in. rods spaced 6 in., centre to centre. Columns are spaced 20 ft. apart throughout; interior columns are 18 by 18 in. in section; wall columns $13\frac{1}{2}$ by 28 in. The first storey is 12 ft. 6 in. in height, floor to floor, the second and third 12 ft. each. Column reinforcement consists of four $1\frac{1}{8}$-in. rods.

Girders are 20 by 12 in. by 20 ft. in span, reinforced with five $1\frac{1}{8}$-in. rods, while beams are spaced 6 ft. 8 in., centre to centre, and have 3-rod reinforcement and a section of 8 by 14 in.

No basement is provided, the ground floor resting on the mean level of the site. This site, which is part of the filled ground known as Potomac Park, alongside the river of the same name, is well adapted to requirements, a minimum of grading having been necessary. To conform to minor differences of level, wings were "stepped" in certain instances.

The staircases are all of reinforced concrete, and are particularly wide—these being the only means of travel from one floor to the other. Besides four main flights located in each headhouse, each wing is provided with two or three supplementary stairways properly situated.

In addition to the gypsum-board and plaster partitions generally used, partitions of a fire-resisting material are placed at intervals, dividing each floor into sections so as to localise any fire that might break out. All openings in these partitions have automatic fire-doors, thus making each section an independent compartment, and the staircases are so placed that egress from one section may be had without passage through any of the others.

The use of steel sash ensured rapidity of construction, large glazed areas affording ample natural lighting, and (where glazed with wire glass) a considerable factor of fire-protection.

The corridor partitions have an unusually large glass area, which makes the corridors cheerful and pleasant on even the dullest days.

Plastering is used on the partitions and inside the curtain walls; ceilings (except that of the third storey), beams, and columns reveal the structural concrete as the forms left it, giving the not disagreeable impression of heavy timber construction. Water-colour paints of harmonious tints are used throughout the interior. The roof structure is identical with the floors, except for a slope of 1 : 20 and 1 : 48 on the headhouses and wings respectively. Pitch-and-gravel over five-ply felt is the roofing material used. A suspended ceiling of gypsum-board and plaster extends over the entire upper floor at a height of 11 ft.

CONSTRUCTION.

It was at first supposed that pile foundations would not be needed, but investigations made during the first two weeks of preliminary work showed the contrary to be true. The area on which the buildings are located proved to be a portion of the old river-bed. To reach solid ground through fill and soft material required piling varying from 20 to 52 ft. in length. Where practicable, concrete piles (cast in place within pre-driven shells) were used ; but in 20 per cent. of the cases the lengths necessary compelled the use of so-called " composite " piling, consisting of a wooden pile surmounted by one of concrete. The total number of piles driven was 5,048, and this work caused a delay in the occupancy of the buildings of about 30 days above the period originally estimated.

Great credit is given the contractor for the skill with which his great resources and organisation were applied to the peculiar difficulties of concrete-placing on this job. The project was extraordinarily thin in distribution, requiring less than 1·9 cu. ft. of material per sq. ft. of ground space occupied. Nevertheless, the bulk of concrete was vast, and it had to be placed with all possible speed.

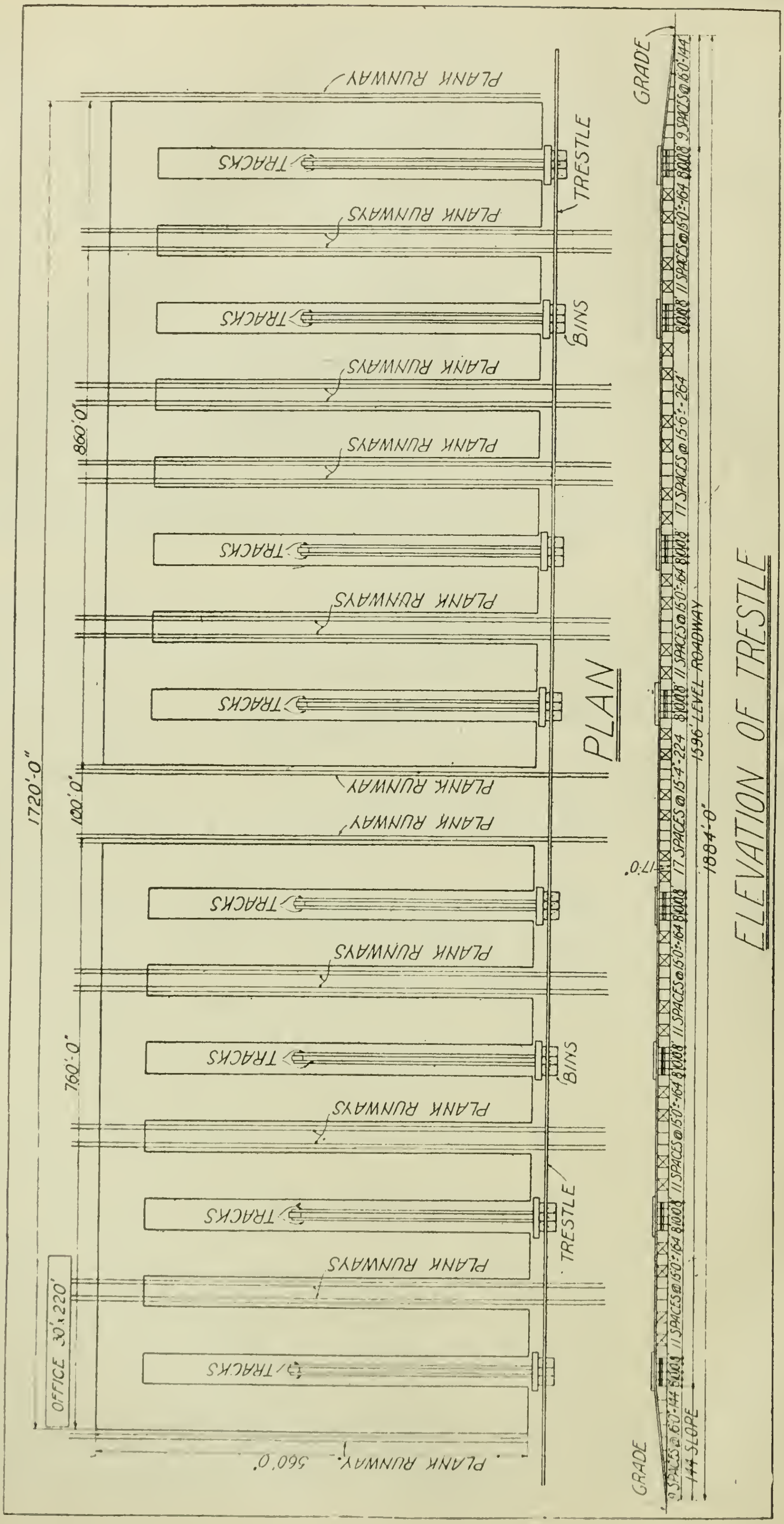
CONSTRUCTION PLANT.

A construction plant was devised which admirably met the conditions. A heavy trestle was built paralleling the entire width of the site (2,200 ft.) at the rear, 17 ft. in height, and having approaches from the street level with a gradient of 11·8 per cent. This trestle was designed to carry 5-ton motor trucks, which brought sand and gravel from nearby river dredgings and cement in bags from a railroad siding adjacent. Eight storage units for this material were placed at intervals underneath the trestle, each provided with separate bins for 55 cu. yd. of sand, 110 cu. yd. of gravel, and a suitable supply of cement. The aggregate bins were covered by gratings of 4 by 12-in. planking set on edge and spaced 4 in. apart. Over the trestle a steady procession of trucks passed from east to west, dumping sand or gravel through the proper gratings, or delivering sacked cement through chutes for storage as needed.

Midway of alternate courts of the buildings under erection were located the mixing plants, each connected with one of the storage bins by a straight track of narrow gauge, at right angles to the trestle and about 300 ft. long. Upon these tracks ran small cars of the industrial type, having separate compartments for sand and gravel, and controlled by an endless rope from a motor near the mixer. Brought to a stop under the trestle, they were automatically loaded with sand and gravel in proper quantities from the bins, and cement being then thrown in on top, they were ready for the return trip to the mixer.

Each mixing plant controlled the concreting of two wings. Each plant comprised a $1\frac{1}{4}$-yd. mixer sunk below ground level, a 40 h.p. electric motor for its operation, and a tower and hoist for the distribution of the mixture.

Concrete was delivered to place in buggies operating at four levels from platforms adjoining the towers, no chuting being employed at any stage. The capacity of each mixing plant, with fifty hands each, was 400 cu. yd. per day, restrictions as to quantity of dry material having been eliminated by the system already described. Since each plant was entirely independent of the rest, the



Lay-out of Contractor's Plant

New Reinforced Concrete Buildings for the War and Navy Departments, Washington, D.C.

theoretical maximum capacity on the job was 3,200 cu. yd. of concrete per 10-hour day, though practical considerations kept the recorded maximum down to 1,750 yds., equivalent to a section of the building 300 ft. long.

The placing of the structural concrete was accomplished in 13½ weeks, an achievement which is believed to have established a record for this type of work. The weekly output was equivalent to a 780-ft., section of the structure while the total yardage of concrete employed on the job was 68,000.

The principal difficulties experienced by the contractor were, however, of a human rather than a mechanical origin.

Common labour was, for obvious reasons, very hard to obtain in the United States, and wages are abnormally high.

The final cost of the project, including an additional item of about 29 acres of linoleum for the office rooms, is $3·95 per sq. ft.—95 cents above the original estimate. This higher cost is largely explained by foundation conditions and the state of the labour market.

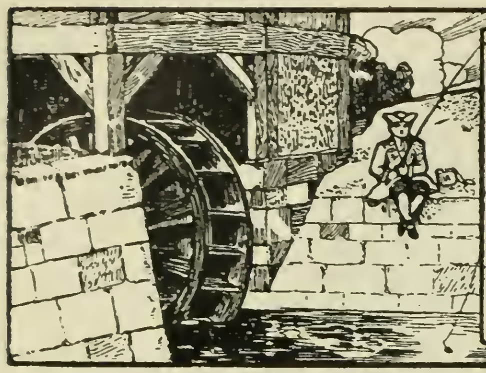
CONCLUSION.

The wings and headhouses, if placed end to end, would form a concrete structure 60 ft. wide, three storeys high, and nearly two miles long.

The accompanying photographs give some idea of the completed appearance of the group, and the drawings show a typical floor-plan and details of the contractor's construction plant.

The project was executed under the general supervision of Commander A. L. Parsons, Civil Engineer Corps, U.S.N., Assistant Chief of the Bureau of Yards and Docks, while the architectural features of the design were developed and agreed upon by a committee from the same Bureau presided over by Lieutenant-Commander F. W. Southworth, U.S.N.

The contractors were the Turner Construction Company, of New York.



THE HOUSING PROBLEM.

Extract from the Report issued by Sir J. Tudor Walter's Committee, appointed by the Local Government Board to consider Questions of Building Construction in connection with the Provision of Dwellings for the Working Classes.

Continued from December Issue.—ED.

PART IX.—ECONOMY IN CONSTRUCTION. (*Continued.*)

184. It appears probable that, in order to carry out the programme of building proposed, in the early stages at any rate, use will have to be made of every kind of suitable material and of all classes of available labour. Several witnesses laid great stress on the importance, in reference to economy and despatch, of adopting methods to which both builders and workmen were accustomed, and we realise that due weight should be given to this consideration. It is also probable that difficulty of transit may increase the ordinary desirability of adopting materials found as near as possible to the locality of the different building schemes.

185. These and other factors will vary in different districts, and will depend upon the extent of the individual scheme under consideration. Introduction of new methods which might prove costly in connection with a small scheme that could most economically be carried out by local builders and labour, might on the other hand result in considerable economy in the case of a large scheme entrusted to an experienced contractor who had opportunities of assembling skilled supervision, labour, materials, and plant for the particular work. Conditions of climate also will have to be considered. Some parts of the country are liable to long-continued, fine rains, accompanied by strong, driving winds which constitute a most searching test. It is found by experience that a particular type of building and a certain thickness of wall which have proved quite satisfactory in one position may fail to keep out the weather on some exposed sites. It must be recognised also that the more open type of lay-out which is recommended for the houses about to be erected involves a somewhat greater degree of exposure to the weather than when houses are built very closely together. In some districts where 9-in. solid brick walls have proved generally satisfactory in narrow streets closely built up, it has been found necessary when adopting the open lay-out to use 11-in. walls ; the greater exposure resulting in driving the wet through the 9-in. walls in places. The difference between sheltered and exposed sites even in the same locality has not sufficiently been taken into account, because the great influence of the wind has not been recognised. This is constantly proved in connection with different types of windows ; types which are perfectly waterproof and satisfactory in some localities are totally inadequate in others.

186. In considering economy in reference to definite materials or individual methods of construction, the interaction of one upon another has also to be remembered ; for example, in regard to the use of stone for walling, the actual cost of the stone wall per square yard may be much less than the cost of brickwork, and yet the cost of a cottage built with the stone walling may be higher than that of the brick cottage. This may be due to the necessity of using dressed stonework in connection with the openings and quoins, and will in many cases be partly due to the increased roof area and width of foundations required for stone walls. The economic use of various forms of door and window frames has also to be borne in mind in connection with the adoption of stone as a walling material; for example, if stone dressings, which have formed a considerable item in the extra cost, were replaced by standardised concrete window frames which could be built directly into the rubble walling, the benefit of the cheaper stone walling would be to some extent realised in the total cost of the cottage. Any constructional suggestions that can be made must, therefore, be judged in each case in relation to the particular circumstances, otherwise they must prove misleading.

STANDARDISATION.

187. There has been some difference of opinion among witnesses as to the degree of standardisation which is desirable, and as to the extent of the economy which may be secured by this means. This difference, however, is partly due to the different aspects of the subject which have been in the minds of the witnesses. By standardisation some have understood the manufacture of complete cottages of two or three standard patterns and the erection of them wherever houses are required; these have in mind the standardisation of plans, designs, and all parts on the lines adopted for the manufacture of a motor-car; others are thinking merely of the standardisation of certain parts, such as doors, windows, fireplaces, etc. The subject cannot, however, be dealt with satisfactorily in this general way, because the desirable limits of standardisation and the extent of economy that can be obtained thereby will vary with each individual part of the cottage.

188. With regard to standardisation of design, there has in the past been a tendency for a very unintelligent standardisation to be adopted by individual speculative builders, who have repeated some single type of house row upon row, and street upon street, without regard to aspect, nature of site, relative position, or any other local conditions. We are convinced that such standardisation cannot be economical, because, as has already been pointed out, it must involve neglect of many opportunities for considerable improvements in the arrangement of the house, and neglect of proper consideration of aspect, nature of site, and the position of each individual house. On the other hand, it will be found both convenient and economical to adopt a series of typical plans adapted to the main circumstances and aspects for which houses will be required; such typical plans can be thought out and arranged to meet the general needs of the householder to an extent which is hardly practicable in the case of each new design. They will, moreover, form a standard for comparison, in reference to which special new designs can be judged, but the limitation of their use as standards should be recognised, and while such plans may be accepted as a general basis, care should be taken to prevent them from becoming too stereotyped.

189. Owing to the probable shortage of timber, it is likely that some substitutes will have to be used for both floors and roofs, and in the case of nearly all such substitutes considerable economy would be secured if standard widths for the main rooms of the house were adopted, so that reinforced concrete or other beams, or centreing for *in situ* concrete floors could be made in standard lengths or sizes. Some standard spans for roofs would also be an advantage, and would enable much cutting and preparation to be done before the roof timbers are sent on to the building. In fixing such standards, the usual trade lengths of the timbers required should be taken into consideration. Where timber floors are used, such definite standardisation of sizes may, if carried too far, be the reverse of economical in that it might create an abnormal demand for particular lengths and particular scantlings of timber. The adoption of certain scantlings of timber for military huts at one time created almost a famine in the particular sections and lengths required, and it became necessary to vary the sizes in order to overcome the difficulty. Where special articles have to be manufactured the adoption of standard lengths or sizes undoubtedly tends to economy, but where they have to be cut from growing timber or obtained from other natural sources, as in the case of slates, any too extensive standardisation is not likely to be economical.

190. Considerable evidence was given upon the question of the standardisation of bricks, opinion being divided as to its practicability. Certain difficulties would no doubt present themselves immediately after the war, since, if an adequate supply of building materials is to be secured, advantage will have to be taken of all the existing brick-making machines and plant as they stand. There is, moreover, considerable objection to standardising the size of bricks on the part of some architects, makers, and others. To be effective, it would have to include glazed bricks, blue bricks, air gratings, etc., and details of construction would be affected in all branches of the building and engineering trades. Hence, while we think that the subject is worthy of further consideration by all parties concerned, we do not feel that it is one of sufficient importance to housebuilding to justify us in making any recommendation on the matter.

191. Certain standard sizes and proportions for doors and windows could be fixed with advantage. Hitherto it has been a common practice with many makers of standardised joinery to vary the height of doors with the width. This is necessary if the same proportion of height to width in each door must be maintained, but for cottage building, where doors of different widths must often be used in order to save space, the effect of having doors of different heights in one room or in one entrance lobby is more unsatisfactory than the difference in proportion; the building is complicated also by the lintels having to be left at different levels; a standard height for all doors would greatly simplify building operations and would lead undoubtedly to economy. Standardised sizes for doors and windows would enable standardised reinforced concrete or other lintels to be made at suitable centres and distributed to the building sites, and in the case of the windows such a course would lead to the standardisation of sashes or casements and of the panes of glass to be fixed in them.

Owing to the large number of houses that will be required, probably the limit of economy in standardisation would be reached even if a number of different standard types were adopted so that a reasonable variety would be available. The conditions which limit the heights and widths of cottage windows are very much the same in all cases; cottage rooms tend towards a standard height of about 8 ft. and the height of the glass line from the floor and from the ceiling cannot vary very much so that a few standard heights would suffice for all requirements. There is no doubt that such standardisation would render practicable the manufacture of concrete window-frames, iron or steel sashes, in addition to wooden sashes and frames, on a scale that would lead to a substantial reduction in the cost; window frames, cheaper in first cost, more durable and involving less periodical outlay for painting would then be available.

192. With regard also to baths, sinks, grates, ironmongery and other fittings, intelligent standardisation would in all probability lead to economy, not always by the reduction in the price of the cheapest articles, but by the production of a much better article in proportion to the cost. There has been a tendency in the production of cottage fittings to manufacture very large numbers of articles of excessive cheapness and inferior quality; while articles of a better quality, on the other hand, have been produced on a much smaller scale and have been sold at a proportionately much higher price; so that the only way to secure a cheap article has been to accept an inferior quality, and the only way to get a good article has been to pay a heavy price owing to the limited extent of production. We are convinced that if good, sound articles, well made and of adequate strength were standardised and produced in sufficiently large quantities much better value could be secured. We recommend that such standard patterns should be carefully worked out and samples prepared, in consultation with both expert manufacturers and those who have studied the uses of the articles. In this way good, strong articles adapted to the purpose for which they are required, suitable in design and involving a minimum of cost in maintenance, should be provided at the lowest cost and in sufficient number of patterns to meet all reasonable desire for variety.

FOUNDATIONS.

193. Good judgment in each case can alone determine the necessary foundations and avoid the expense incurred in providing more extensive foundations than are required. There are, however, a few general conditions which may be indicated. It has been pointed out to us that footings twice the width of the wall are frequently required in addition to a concrete bed. It seems clear that, where an adequate cement concrete foundation is used, the brick wall could be laid without footings directly on the surface of the concrete without weakening the foundation. Frequently it would be found more economical to put in the whole of the foundations up to the finished ground level in concrete, and, if this were done, the extra depth of solid concrete would add very greatly to the strength of the foundations and enable them to resist movement due to difference in the degree of bearing power in the ground. Such considerations apply especially to clay subsoil; the expansion of clay when wet and its contraction when dry, as well as the plastic character of moist clay under pressure, render this a foundation always requiring care. It is necessary to carry excavations deeper in clay than in most soils, because in a dry season the clay may shrink to a considerable depth and to an extent that would materially affect a building; the shrinkage, moreover, is liable to be repeated year after year. Some reinforcement in the concrete foundation of the main walls may, therefore, be economical in the case of a clay soil; it will prevent the foundations being so readily affected by movement in the clay and minimise the deleterious effect that may result from such movement. The actual weights per square foot of the foundations imposed by ordinary cottage buildings are light; trouble in the foundations usually does not result from overweighting the ground so much as from the fact that the ground itself varies in its bearing power on account of expansion and contraction at different seasons of the year, and thus tends to produce gradual movement in the building. In such case a base wall of concrete laid with the foundation up to ground level or to the underside of the floor of the building will add very greatly to its strength and is strongly recommended.

194. In mining areas where serious settlement of the ground is liable to occur, the foundation should be strengthened with suitable reinforcement. Steel rods, old rails or steel wire ropes, which have served their time for mining purposes, may be used. Where beds of running sand, peat or other materials affording an unreliable foundation are met with, a reinforced concrete raft will often prove the most satisfactory and economical base upon which to build the house.

195. In connection with many of the proposed new materials for walls, such as concrete slabs, hollow terra-cotta slabs, reinforced concrete uprights with slab filling, etc., it seems probable that a rigid base will be an important element in the stability of such types of walling, probably more important than in the case of ordinary brick or stone walls, which, owing to their numerous joints and small units of rigid material, can give much more readily to slight movements than can thin walls built of large slabs, particularly if set in cement mortar.

196. Where the subsoil consists of gravel or other similar material not affected as to its stability by changes in moisture or temperature, no considerable depth of foundations is necessary, provided that there is no movement of water tending to remove the finer sand from among the gravel; this, however, is a difficulty not often met with. In many districts there may be found a good lime sufficiently hydraulic in character to set thoroughly for the foundations, and where such lime is available it may prove less costly than cement for making concrete. On the other hand, a much smaller proportion of cement to aggregate will make a good concrete, so that the relative cost of the two methods cannot be judges alone by the price of the materials. In other districts a good foundation on ordinary subsoils is made with local naturally-bedded stone; a layer of such stones which can be used and with very little labour may effectively distribute the weight of the wall upon the ground. Local byelaws and regulations should certainly provide for any such suitable foundations and should not require brick footings in cases where they are clearly unnecessary.

WALLS.

197. The walling of a cottage has to be considered from three main points of view—stability, weatherproof properties and freedom from liability to condensation on the inside.

198. In the case of ordinary building materials, the thicknesses which will provide adequately for resisting the weather will usually afford sufficient stability, considering the light weights and general distribution of load usually found in cottage buildings; but with certain new materials, particularly concrete and terra-cotta slabs, a sufficiently weather-proof wall may be provided with such slight thickness as to raise a serious question in reference to stability; moreover, the question of stability in the thinner types of wall is complicated by the fact already referred to that in a large number of cases the foundations of a cottage cannot be considered as absolutely rigid. In considering stability in reference to the long period of 100 years or so during which the majority of cottages built of ordinary materials may be expected to last, the effect of repeated slight movements in the foundations must be allowed for, and is not easy to determine except as the result of experience over a long period. Nevertheless, it is fairly obvious that movements of any kind tending to bend the foundation must have a more serious effect on such types of wall, and before adopting them due consideration should be given as to whether the nature of the subsoil or the character of the foundations will afford a base of such rigidity as to justify their adoption.

199. A good house wall must be built to resist the weather and also to protect the inside of the house from the too rapid influence of excessive heat or cold. In addition, the wall and its interior finish must be of a nature to resist undue condensation; there is no doubt that many walls have been condemned as not weather-proof because of what is often described as " sweating," but which is frequently due to condensation, or perhaps in some rare cases may be due to the hygroscopic nature of the material of the wall itself. Condensation of moisture must always occur when relatively warm moisture-laden air comes in contact with a relatively cold surface. Whether actual sweating takes place to the extent of forming beads of moisture which accumulate and run down the wall depends on two qualities in the wall—the porosity of the surface which will enable a certain amount of moisture to be absorbed into its substance and the low degree of its conductivity which will permit the layer of the wall adjacent to the warmer air to accumulate sufficient warmth to check condensation. The conditions in which most violent condensation takes place, usually arise when there is sudden thaw after a long-continued frost; during the frost the temperature of the whole of the walls of the building may have fallen to below freezing point; a thaw often is accompanied by a warm moisture-laden atmosphere; such an atmosphere fills the house and the cold surface of the wall condenses the moisture. Where the surface is smooth and impervious, as, for example, on a painted wall, the moisture very rapidly deposits in beads and begins to run down the wall in streams; many of the modern hard plasters have the effect of producing heavy condensation. The degree of conductivity in the plaster itself and in the material of the wall also influences the result. A thick wallpaper will often act as a non-conducting medium insulating the warm air from the cold wall and reducing the amount of condensation, while at the same time it may absorb a certain amount of moisture which, however, does not show in the form of drops of water and soon dries out. It appears, therefore, that to produce a satisfactory condition the inner surface of the wall should be as good a non-conductor of heat as possible and should be reasonably porous, and that surface precautions are particularly necessary in connection with non-porous types of walling, or walling composed of materials which are good conductors of heat. Where walls are very thin and are good conductors of heat, condensation may occur during the continuance of cold weather owing to the rapid absorption of heat from the room, producing an effect less in degree but of the same nature as the condensation which takes place on an ordinary window pane in frosty weather. This type of condensation has to be guarded against in the case of thin concrete slab walls and is not present where walls are sufficiently thick to impose considerable resistance to the passage of heat from the room to the outer surface of the wall.

200. In addition to the transference of heat and the question of condensation as affecting walls, there may be some difference in the degree of purification of the atmosphere of a room which may take place as between a porous wall and one which is impervious. We have found very little data existing which would enable exact comparisons to be made between walls of stone, bricks, concrete slabs, terra-cotta blocks, etc.; we have, therefore, arranged for experiments to be made with a view to arriving at some definite comparative values, both in reference to the transmission of moisture and heat, and to condensation and purification of the air. It is sufficiently clear, however, that the question of condensation has proved a somewhat troublesome one in connection with certain types of walling, and that, if their use is to be adopted, reasonable precautions should be taken.

201. In regard to the resistance to weather, most materials are not quite impervious, and the thickness of the wall in relation to the maximum duration of the severe test of driving rain usually determined in the older types of walling whether an adequate degree of weather-proofness was attained. A certain degree of similarity of texture and density between the bricks or stones and the mortar used to connect them is desirable. Certain bricks, which are very impervious, give such an indifferent hold to the mortar owing to their smooth surface that wet sometimes finds its way between the mortar and the brick. Some of these bricks have a very fine dust adhering to them, and unless well wetted may in places fail to adhere completely to the mortar. Hence it sometimes happens that bricks of a more sandy character and rather less impervious will on the whole give a more satisfactory wall.

202. In exposed districts the dryness of the inner surface of the house has largely been secured by some form of cavity. In some districts this cavity was arrived at in a rough-and-ready way by omitting the mortar from the centre of a thick stone wall. In Scotland it has usually been provided on the inner surface of the wall by strapping the wall, the plaster being laid down on laths nailed to thin wooden battens, thus creating a cavity between the wall and the back of the plaster. More recently the cavity brick wall has been generally adopted, and has been in use for such a period as to remove any doubts that may have been entertained as to its permanent stability. By introducing a complete cavity between the inner and outer portions of the wall, and by using, to connect and tie together these portions, wall-ties that cannot convey moisture from the outer to the inner portions, it is possible to secure a perfectly dry inner wall, even when the outer portion is not entirely impervious to damp. The most common form of wall-tie is that made of galvanised iron with a twist or a loop so formed that any wet running along the tie will drop off before reaching the inner surface of the wall. Vitrified bricks are also made for this purpose, these generally slope downwards one course between the inner and the outer portions of the wall, and usually do not extend to the full thickness of the wall, the end being covered by a cut brick, so that on the outer surface the facing brick may be maintained unbroken. A very good method of using these tie-bricks, though possibly somewhat more costly, is to build them in continuous horizontal courses ; one course immediately under the roof plate, one under the plate of the first floor, and two intermediate courses, making four in all in the height of a cottage. This method not only thoroughly unites the inner and outer walls, but enables both the outer and inner wall to bear some of the weight of the floors and roof. It also prevents the passage of vermin, and stops the transmission of sound from floor to floor. Any damp coming through the outer wall is checked by the horizontal courses and directed to the outer wall, instead of collecting at the bottom of the cavity. Any mortar droppings that fall on these courses can readily be raked out of the cavity through the reveals of windows and door openings before the window and door frames are fixed. Several new forms of wall-tie have been suggested ; one is constructed of steel encased with impervious artificial stone, which affords a very good grip in the joints and would appear to give protection to the metal against rust. The stability of the cavity wall must mainly depend on the efficiency of the wall-ties ; so long as these give an adequate bond between the two parts of the wall, so that it may be regarded as a rigid whole, there is comparatively little loss of strength owing to the hollow form, but there must be considerable loss should the wall-ties fail. Hence it is important to use wall-ties which will not serve as medium for conveying damp across the cavity and which will not be liable to snap on account of settlement or to rust or perish owing to damp or atmospheric changes over a long period of years.

203. There are certain other points of difficulty in reference to cavity walls which have to be considered :—

1. Mortar droppings are liable to accumulate at the bottom of the cavity ; for this reason it is most desirable that the cavity chould be carried down two or three courses below the damp course, so that such droppings may not be a medium for conveying damp to the inside of the wall above the level of the damp-course. This accumulation of droppings is not avoided altogether, even when a board is kept in the cavity and drawn up as the work proceeds.

2. In the case of all heads or lintels which cross the cavity, there is a chance that damp running down the outer portion of the wall may accumulate on the lintel and penetrate to the interior. Where concrete lintels are used the upper surface should be sloped outwards and if the concrete is itself sufficiently water-proof no difficulty should arise, otherwise a layer of thin bitumen or other damp-course material

should be laid over the lintel to throw off the wet, and this method should always be adopted where wooden lintels or frames occur in the cavity.

3. At the sides or jambs of openings also there is a difficulty in stopping the cavity effectively; if the last course of bricks is bonded across, it becomes a definite medium which frequently conveys damp; on the other hand, if the cavity is left entirely open, damp is liable to get at the wooden frames and set up decay or even strike through into the inside of the building. It is best that the ends of the cavity should be closed with some impervious substance; a course of slates or vitrified tiles laid on edge in cement across the cavity may serve effectively, and, if standardised concrete frames should be adopted, they might be grooved or otherwise treated to form an effective stop to the cavity and to resist any tendency for damp to cross.

4. The question of the ventilation of the cavity is one about which there is a difference of opinion; some witnesses advocate that the cavity should not be ventilated at all, in order that the insulation due to the air space should have its maximum effect in resisting change of temperature. On the other hand, others urge that, considering the possibility of vermin getting into the cavity and the fact that the air from the cavity must slowly, at any rate, have access to the rooms inside the house, it is undesirable to leave the cavity without exterior ventilation. It is obviously important that the cavity should so far as practicable be closed to any access by vermin both inside and outside. Perhaps the best plan is to provide sufficient ventilation in the cavity to prevent the accumulation of anything objectionable, but not sufficient to cause such a rapid change in the air of the cavity as would materially diminish its value from the point of view of insulation. Such ventilation can readily be provided by leaving here and there a dry vertical joint between the bricks in the exterior face of the wall. The space so left would not be sufficient to admit vermin but would provide for the necessary slight change of the cavity air.

204. The above considerations in reference to cavity walls apply generally whether the walls are constructed of brick or of concrete or other slabs. In all cases it should be remembered in connection with the cavity wall that the functions of the exterior and interior portions are different; the weight of the upper floors and very often also of the roof, and the concentrated load due to any floor beam or roof truss are usually carried mainly by the internal portion of the wall; from the point of view of stability, therefore, the internal portion is the more important. Apart from the consideration, the comfort of the house, as we have already seen in reference to the question of condensation, depends on the internal portion of the wall being of a porous and non-conducting nature. These qualities are apt to be associated with concrete of insufficient strength, and for this reason it is probable that the interior half of the cavity concrete wall should be substantially thicker than the exterior portion; the degree to which this is necessary and desirable will depend to some extent on the efficiency of the wall-ties. The exterior portion, on the other hand, while it has little direct weight to carry, must be able to resist the weather, and must be either completely impervious or of such a thickness that a mild degree of permeability does not affect its practical weather-resisting power. It must be of sufficient strength to resist both the disintegrating effects of weather, and rough usage to which the outside wall of a building may occasionally be liable; this latter consideration is certainly one of importance when considering such materials as the thin hollow brick or tile blocks which have been suggested, and also thin sheet compounds of cement, asbestos or other materials, many of which may be quite adequate to turn the weather, but, on the other hand, may easily be broken by a sharp blow. Such rough treatment may be due to children or occasional accidents which are more liable to happen to the lower parts of buildings than to the upper. Materials, therefore, which might prove satisfactory for the upper storey of a cottage might be too susceptible to such accidental damage to be wisely used for the lower storey. The old-fashioned tile or slate hanging or plaster surface on timber-framing are good examples of materials which have proved durable over very long periods in the upper parts of houses, but have not proved satisfactory on the ground floor.

205. In comparing concrete walling with brick, it is desirable to dispel at the outset the idea that there can be any sensational amount of saving by the use of one material or the other in those districts where good bricks are made and where there is also available a good aggregate for concrete. Suitable clay for brickmaking and suitable aggregates for concrete are both raw materials readily available at low cost. Brickmaking involves the use of a fair quantity of fuel and labour, though mostly not of a very skilled description. The aggregate for concrete in the majority of cases would require preparation by crushing, grading and mixing, while the cement which represents only about one-sixth of the bulk of the concrete, and is obtained from raw materials equally inexpensive, involves a rather more elaborate process of manufacture. Certain types of concrete walling involve less labour and less skilled labour than brick walls; but on the other hand, greater skill may be required in the supervision of concrete construction generally. Moreover, both workmen and masters have experience and understanding of brick walls, but have not yet acquired the same experience in reference to concrete. The conditions, therefore, suggest that any considerable difference in the cost of building with one or other material is likely to depend mainly on local conditions, such as the presence or absence in the neighbourhood of suitable aggregates for concrete or of suitable brick earth and brickworks. Although brick earth abounds in this country in variety and to an extent found perhaps in few countries, there are large districts devoid of suitable material for the making of bricks, and in some of these districts there will be found gravel and sand ready mixed in proportions that will make good concrete; in such districts concrete should prove substantially less costly than brick.

206. The variety of aggregates which may be used for concrete is very considerable. The following may be named to indicate some of these varieties :—

NATURAL MATERIALS.

Pit and River Gravel.
Beach Shingle.
Granite.
Basalt.
Trap.
Lavas.
Pumice.
Sandstone.
Quartzite.
Limestone.
Flints.
Chalk (hard).

ARTIFICIAL MATERIALS.

Coke Breeze.
Furnace Clinker.
Boiler-house Ashes or Cinders.
Blast Furnace Slag.
Burnt Clay.
Burnt Shale.
Broken Bricks.
Broken Terra-cotta or Pottery.

In the case of some of these materials, however, the question of chemical action owing to the presence of sulphur, lime, coal, or other impurities, has to be considered. Coke breeze—by which is meant the residue from coke ovens and gas retorts—furnace clinker, and boiler-house ashes or cinders, have been very extensively used, because with these aggregates it is possible to obtain concrete strong enough for many purposes, light and easy to handle, and sufficiently penetrable to enable nails to be driven and capable of affording sufficient grip for them. Where such materials are used in the manufacture of slabs which are allowed adequate time to mature before being built in, the danger of trouble from impurities is greatly reduced, but accidents have occurred through the use of such materials. In some cases floors constructed of breeze concrete laid *in situ* have expanded and pushed out the main walls of the building; in other cases, concrete window dressings, owing to some disintegrating chemical action set up between the cement and the breeze, have elongated, lifted the upper part of the walls, and generally cracked the building. Several engineers experienced in concrete construction stated in evidence that on account of such difficulties they had given up using these materials for concrete, and relied entirely on sand, gravel, crushed stone, etc. On the other hand equally expert engineers have stated that with proper care slag, clinker and breeze can safely be used, and there is evidence of such extensive use of these materials without any ill effects that it would seem wiser not to abandon them on account of the risk in certain cases, but to seek to eliminate such risk and take precautions which would minimise the danger. Any material containing lime, coal or more that 2 per cent. of sulphur should be looked upon with suspicion, and the aggregate should be avoided if sulphur is present wholly or partially in the form of sulphides or other chemical compounds liable to set up action with the constituents of cement. Very large quantities of suitable material of these classes can, however, be obtained. If crushed, graded, washed and left to weather for a time before being used, many of the dangerous substances may become inert. Sometimes the majority of the dangerous substances can be eliminated by removing the finest of the material and replacing it with sand. Some investigation of this question is desirable, so that definite rules can be laid down for the safe and economical use of this and other classes of material, and research is being made thereon.

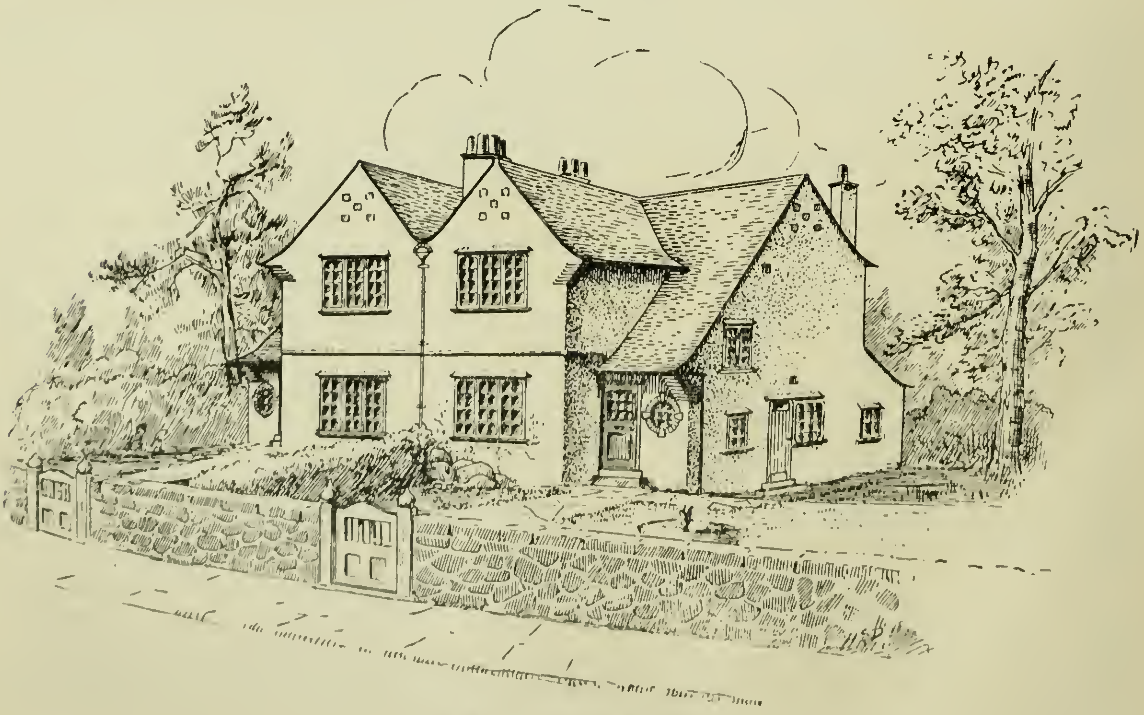
OTHER HOUSING NOTES.

The following notes and illustrations refer to a pair of concrete houses designed by Mr. C. D. Leng, of Sandygate, Sheffield.—ED.

THE two houses here illustrated were built in 1915 on the Calway cavity-wall system. We give below Mr. Leng's own notes describing the erection of the houses : " To begin with, broken stone and sand were used as aggregate, but when it was found that clean boiler ashes or clinker would cost 2s. 0d. per load delivered, as against 4s. per load for broken stone, the clinker was used and the result was quite satisfactory.

" After putting down a slab of concrete covering the entire site to be occupied by the houses, the Calway mould or box was used. This box is filled with damp concrete, which is rammed tight, the inside core is removed, the box unscrewed and slid along, leaving behind a cavity wall 12 in. high.

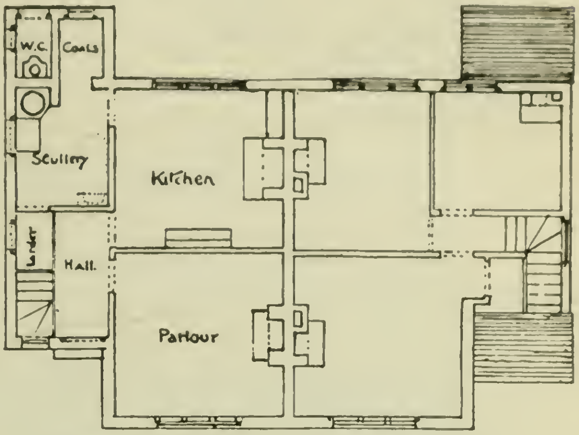
" The process is continued until the outline of the house has been completed, 12 in. in height. On the following day the mould box works on the top of the 12 in. wall, so that in 21 working days 21 ft. high of outside cavity walling has been completed, the whole forming one unit with no joints.



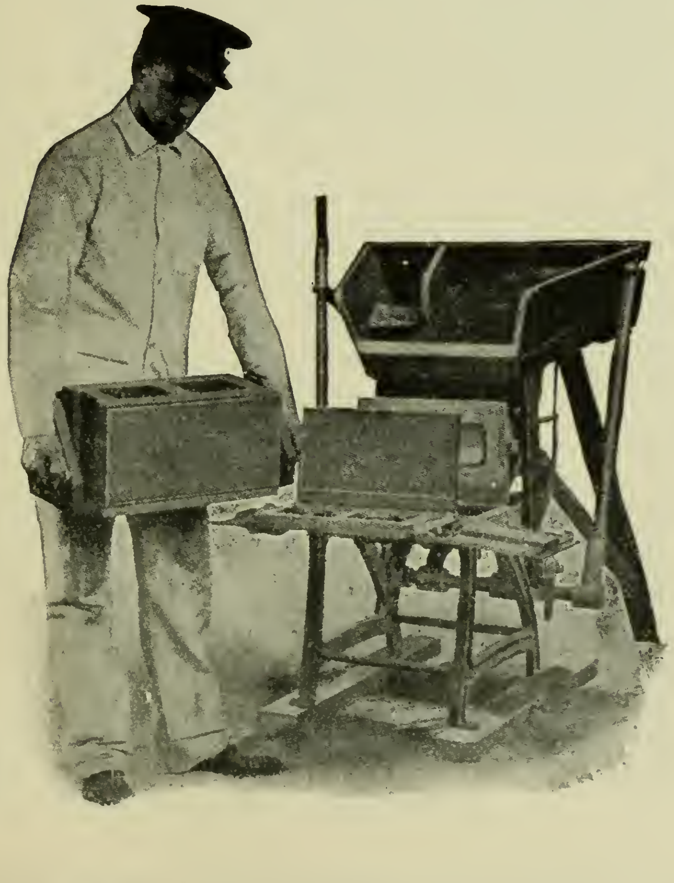
GENERAL VIEW OF HOUSES.

"The outer wall is finished rough cast, and colour washed a deep cream. On the roof timbers a good quality of stiff felt was nailed down, each sheet overlapping the one below and being stuck down with hot tar, with the result that the roof was windproof and snowproof. Then the spars were nailed on and the tiles added.

"The parlour and kitchen both measure 13 ft. by 12 ft. 3 in. These houses, although in a very exposed position, are absolutely dry, warm in winter and cool in summer, and I think they demonstrate that concrete houses need not be plain or ugly. The cost was £800 the pair, and the houses are let for 10s. each per week, the tenants paying the rates. Each house has a bath and a hot water (copper) cylinder, also a gas-heated copper for clothes washing, and the fireplaces and overmantels are good and artistic. With the Calway mould three men can build 25 ft. super of 9-in. cavity walling in an hour. I understand that this process is much cheaper than brick, especially where sand and pebbles or clinker can be obtained close at hand. The concrete consists of 5 parts of stone or clinker, 2 parts of sand or riddled clinker, and 1 part best cement, mixed with 19 per cent. of water and rammed solid."



GROUND · PLAN. | FIRST · FLOOR



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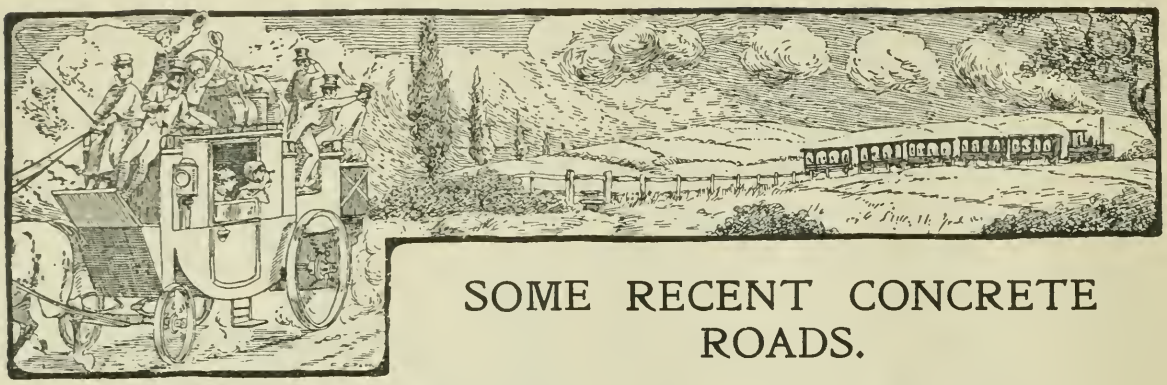


SOME RECENT CONCRETE ROADS.

The following are particulars of some recent concrete road developments, and we are indebted for our information and illustrations to the British Reinforced Concrete Engineering Co., Ltd.[1] *The notes on the road at Southampton Dock were prepared by Mr. F. E. Wentworth-Shields and published in a recent issue of "Road Reinforcement."—ED.*

CONCRETE ROAD AT SOUTHAMPTON DOCKS.

THIS road, of which an illustration is shown in *Fig.* 1, was laid down at Southampton Docks in the summer of 1917. It is 342 ft. long, 25 ft. wide, and 6 in. thick, and has no paths or kerbs. It is level longitudinally, but has a transverse camber of 4 in. (about $\frac{5}{16}$ in. per foot). The greater part is straight, but at one end it has a curve of about 100 yd. radius. It approaches one of the most important quays, where vessels up to 20,000 tons are berthed, and consequently has to sustain a fairly heavy traffic of all kinds. The ground in this neighbourhood was reclaimed from the estuary some years ago, the filling consisting of broken chalk several feet in thickness and overlying the original river mud. The site of the road had, however, been in use for about 20 years, so that the ground was fairly well consolidated. Before the new concrete was laid down the road paving had consisted of water-bound macadam resting on about 1 ft. of hard core, which again rested on the chalk filling. The latter had settled so much that in places it was necessary to raise the road as much as a foot. This was effected by covering the old macadam with ashes, which were consolidated by watering and rolling with a 10-ton roller, the surface being finished off with a camber ready to receive the concrete. The new pavement was made with British standard Portland cement, and sea gravel dredged from Langston harbour. It was 6 in. thick in all, the lower 4 in. being mixed in proportion of 1 to 6, and the upper 2 in. in the proportion of 1 to 3. For this upper layer, the gravel was all passed through a $\frac{3}{8}$-in. square mesh screen so as to avoid the possibility of the road surface being pitted by the splintering of large pebbles. In the lower layer of the concrete, and 2 in. from its under surface, was placed one thickness of B.R.C. Fabric, No. 9, the longitudinal wires being $\frac{7}{32}$ in. in diameter and 3 in. apart, and the transverse wires being $\frac{1}{8}$ in. in diameter and 12 in. apart, and electrically welded to the former. This was supplied in rolls 80 yd. long and 7 ft. wide. Four widths were used to extend over the 25 ft. width of the road, thus giving about 12 in. overlap. A similar overlap was given transversely where a roll ended.

While carrying out the work it was fortunately possible to divert traffic on to a temporary road. After rolling the base, the first operation was to lay down the Fabric, which was weighted and kept from touching the base by 2-in. pebbles or pieces of brick here and there. On the curved part of the road the Fabric was laid parallel to the straight part and sheared off at the sides to suit the curve. Immediately before concreting the base was well wetted. Unfortunately no machine mixer was available, but the concrete was very carefully hand-mixed, being turned three times dry and three times wet before casting into position; the consistency of the concrete was moderately wet. A length of 12 ft. to 15 ft. only was started every day, so as to be certain of finishing the whole thickness before evening. This ensured fine concrete on top being incorporated with the coarser concrete below. Each day's work was finished off against temporary timber templates fastened on pegs at the sides and ends, the surface being formed by working a straight-edge longitudinally backwards and forwards on the end templates. By this means a fairly smooth surface was obtained and no rendering or touching up was necessary. To prevent the possibility of the surface being spoilt by rain at night, it was covered for twenty-four hours with a tarpaulin sheet, which was supported so that it did not touch the green concrete. After a length had been concreted, the next was omitted for a while, and the alternate length concreted. Each length was left until it was about a week old, when the intervening lengths were concreted. No attempt was made to form any sort of expansion joint, the concrete being simply shovelled up against the older concrete face. The work occupied five weeks; it was then left for another five weeks—viz., till October 9th, 1917, when the traffic was turned on to it. As soon as weather conditions permitted (which was in November, 1917), the whole of the surface was served with a coat of hot tar, and dusted over with coarse sand.

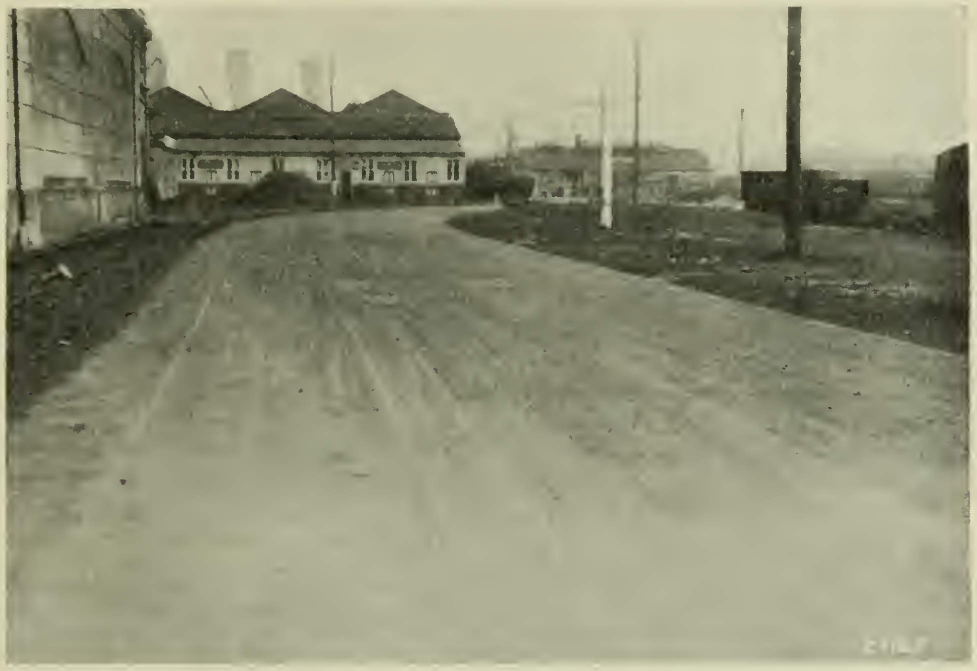


FIG. 1. REINFORCED CONCRETE DOCK ROAD, SOUTHAMPTON, FOR LONDON & SOUTH-WESTERN RLY.

The road has stood the traffic so far exceedingly well, and although of course, a slight crack is visible at the joint of each day's work, there is no sign of deterioration here or elsewhere. The surface is not slippery, and the road has given general satisfaction.

CONCRETE ROADS AT GLEBE ISLAND, SYDNEY, N.S.W., AND AT WISCONSIN, U.S.A.

Fig. 2 shows a road at Glebe Island, Sydney, New South Wales, and is a test road recently laid there with a view to considerable future work, if this test proves satisfactory.

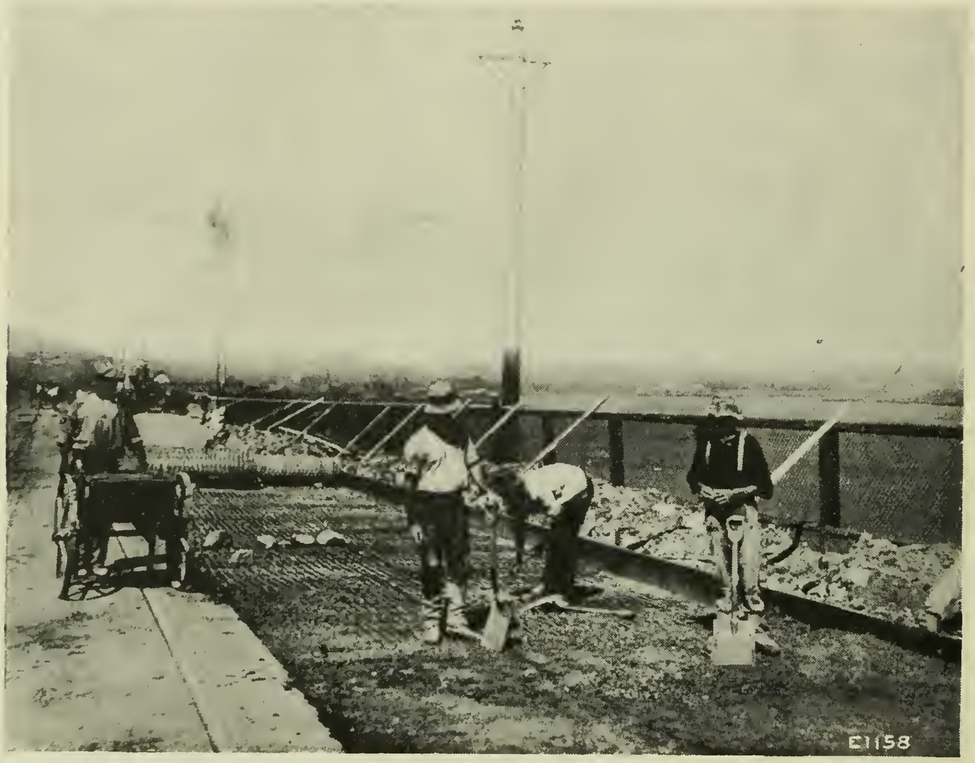


FIG. 2. A TRIAL CONCRETE ROAD AT GLEBE ISLAND, SYDNEY, NEW SOUTH WALES.

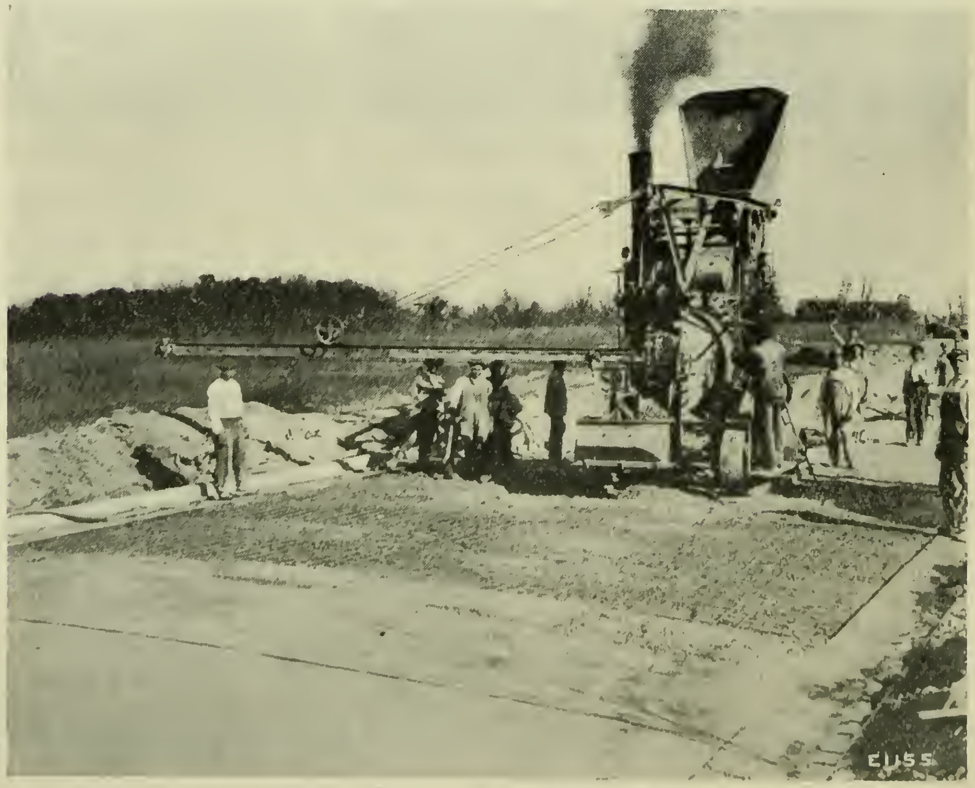


FIG. 3. ROAD AT WISCONSIN, U.S.A.

Fig. 3 shows a concrete road in course of construction at Wisconsin, and gives a clear view of the concrete mixer in operation.

The same form of reinforcement was used in these two roads as in the other two described in this article.

CONCRETE ROAD AT LOCH DOON.

In our frontispiece we show a camp road in Scotland. This road is about 700 yds. long and 16 ft. wide. It leads down to the lake from a road which runs along the side of the lake, and some distance off. The latter road is of macadam and in some cases had been filled in several feet in thickness, but was still subsiding, and it was for this reason that it was decided to try reinforced concrete for the road down to the lake. The ground is boggy, but was drained by a system of field drains and ditches. The road was then laid directly on top of the grass, which was fairly level, and any small hollows were filled up with stones, but there was no pitching and no rolling. It was understood at the time that the road was entirely experimental and nobody expected it to carry the heavy traffic without showing some defects, although it was hoped that it would be better than the macadam road. We are informed that the result has exceeded all expectations, as the road has carried all the traffic in connection with dismantling the camp at the Loch Doon Aerial Gunnery School and does not show the slightest defect. The surface is coated with tar spray and granite chips.

The road was constructed in July, 1917. The concrete is 7 in. to 9 in. thick, reinforced with B.R.C. Fabric.

MEMORANDA.

Concrete Roads in New Zealand.—Bonds amounting to over $600,000 have been issued by the City of Auckland, New Zealand, for the building of several miles of concrete street. This improvement, it is stated in *Commerce Reports*, will give the city from 12 to 16 miles of up-to-date streets, and there is now under construction or already financed about 23,000 sq. yds. of concreting on two thoroughfares of the city. This class of pavement, it is stated, has been found very satisfactory.

A Year's Concrete Road Building in the State of Washington.—Concrete for road construction would appear to be still increasing in favour in the United States. We learn from the *Engineering and Cement World* that road contracts in the State of Washington provide for 100 miles of permanent concrete highway, 90 per cent. of which were completed prior to January 1st, 1919. The area of work under these contracts measures up to about 1,000,000 sq. yds., and the amount of cement required for this class of road is one barrel for every three sq. yards, or over 300,000 barrels for the year's work.

All these roads have been constructed on the one-course method, and the proportions adopted are 1 : 2 : 3. The thickness of the concrete is, for the most part, 5½ in. at the shoulders, and 7 in. at the crown, although there are 30 miles of road in which the concrete is 6 in. thick at the edge and 8 in. at the centre. Most of this work is done with county funds, and the 100 miles referred to is distributed over 14 counties.

The inspectors of the Portland Cement Association, from its Seattle offices, have constantly given attention to the methods of laying concrete roads, in an endeavour to see that the reputation of cement for good roads does not suffer on account of bad practices in preparation and construction.

ASBESTOS CEMENT.

PART II.

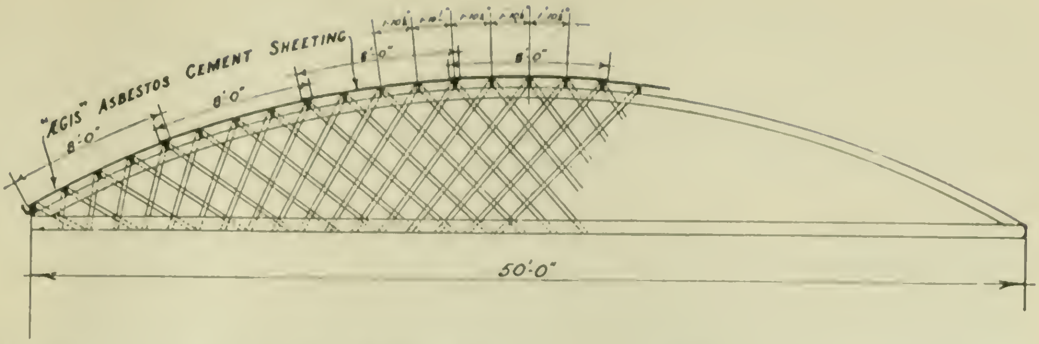
There has been a considerable increase in the use of asbestos cement in the building industry during recent years, and the following notes should be of interest. The first article on this subject appeared in our issue of December, 1918.—ED.

ROOFING.

In the case of roofing work, several types can be adopted, as the material is available in three colours—grey (the natural colour), blue, and red; and the shape may either be square, laid diagonally on the roof, or a corrugated tile can be used with good effect. Sheets may also be adopted as a roof covering, and an example of these showing the method of fixing is illustrated in *Fig.* 5. The drawing shows the application to the Belfast type, but it is equally applicable to the ordinary sloping roof, and the sheets can also be used in connection with steel trusses. Alternate methods of forming the side joints are given, these being either lapped or butted, and in the latter case a wood strip is used to cover the edges, while in both instances asbestos mastic is adopted to give a tight joint and prevent any leakage by capillary attraction. This is a very light form of roofing, and large areas can be quickly covered. Sheets are also made with corrugations similar to those adopted for corrugated iron sheeting, and the pitch of the corrugations as made in this country is 3 in., both for iron and asbestos, whereas the pitch for foreign asbestos is 2½ in., thus the British material can be used to repair roofs composed of corrugated iron sheets, but the foreign material is useless for this purpose.

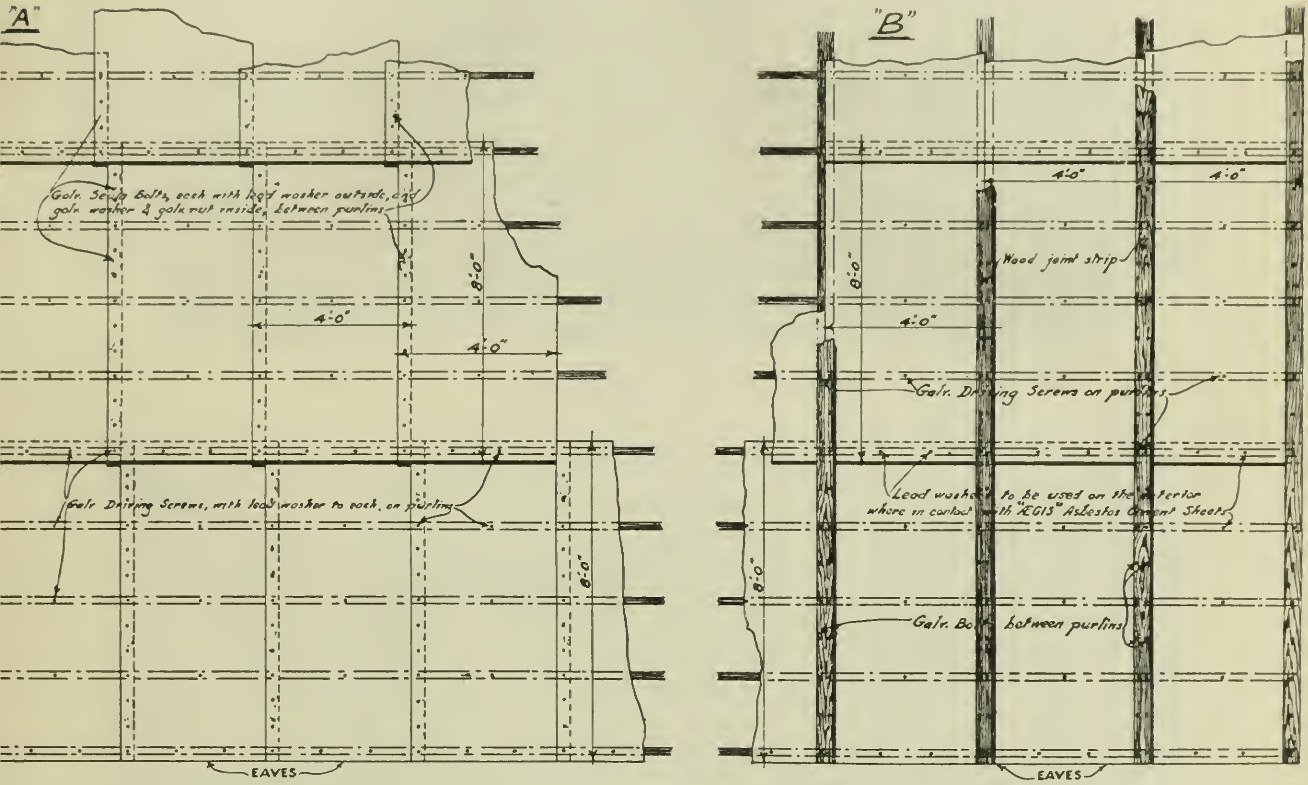
An example of the diagonal method of roofing is given in *Fig.* 7, where the general appearance and method of laying can be clearly seen. This photograph shows a portion of the roof to the premises of the Tyre, Yarns, and Fabric Weavers, Ltd., Castleton—architect, Mr. Sidney Stott, Oldham—and the total area covered with these asbestos cement slates in this building amounts to nearly a quarter of a million square feet. The underside of this roof is also covered with asbestos cement in the form of sheets, which are attached to the underside of the rafters, and fixed with butt joints covered with narrow strips of the same material.

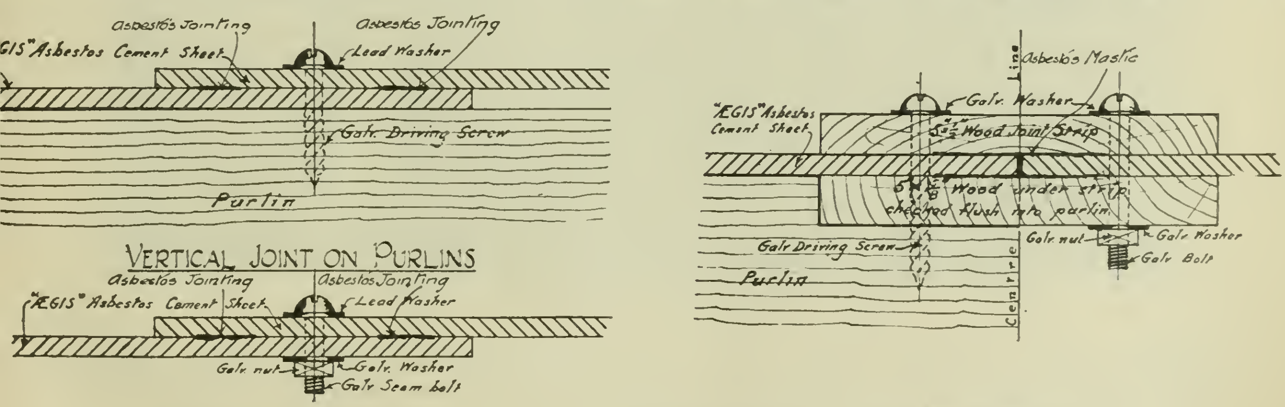
The use of the slates in domestic work is shown in the illustration of a bungalow, *Fig.* 6, this being an exterior view of the building described in connection with *Fig.* 1. The fixing of the slates is very simple, and they may be used in conjunction with a boarded roof or ordinary battens, with a lap which varies from 2 in. to 3 in., according to the pitch of the roof, and whether in an exposed situation or otherwise. Each slate is nailed with two nails, and in addition a copper rivet is placed between the butting edges of two lower slates, with the head below, and the shank is passed through a hole pierced in the point of the upper slate, and after the nailing is complete the rivet is bent over to clip this slate and hold it down securely. The slates are easily cut to shape, and those for the eaves course are formed by scratching a line with a pointed tool at the required position, and then breaking off over a sharp square edge. With a



Alternative developed roof plans—sheets laid with horizontal and vertical joints lapped.

Sheets laid with vertical joints butted and horizontal joints lapped.


"A"
Galv. Seam Bolts, each with lead washer outside, and galv. washer & galv. nut inside, between purlins
4'-0"
4'-0"
8'-0"
8'-0"
Galv. Driving Screws, with lead washer to each, on purlins
EAVES
"B"
4'-0"
4'-0"
4'-0"
8'-0"
8'-0"
Wood joint strip
Galv. Driving Screws on purlins
Lead washers to be used on the exterior where in contact with "ÆGIS" Asbestos Cement Sheets
Galv. Bolts between purlins
EAVES



Vertical joint between purlins.

Vertical joint—half on purlins, half between purlins.

Fig. 5. Roofing with Asbestos Cement Sheets.

2-in. lap the weight of the slates is only 18 lb. per sq. yd., and thus it will be seen that they compare very favourably with ordinary slates in this respect.

A more recent form of asbestos cement tile, and one that possesses several advantages, is the corrugated variety. These are strong and light, and being made in a large size they can be fixed direct to purline, spaced at about 3 ft. 6 in. centres, without the introduction of common rafters or battens. An illustration of Messrs. Turner's Trafford Tiles is given in *Fig.* 9, and it will be seen that the fixing can be made to steel angle purline without any wood whatever, and thus a highly fire-resisting roof is obtained. The standard size of these tiles is 4 ft. by 3 ft. 8 in., and with a horizontal lap of 6 in., only 8·57 tiles are required to cover 100 sq. ft., while the weight of one hundred tiles ¼ in. thick is only 34 cwt. The side lap is equal to one corrugation, and the fixing to steel is accomplished with either hook bolts or straps, and to wood-

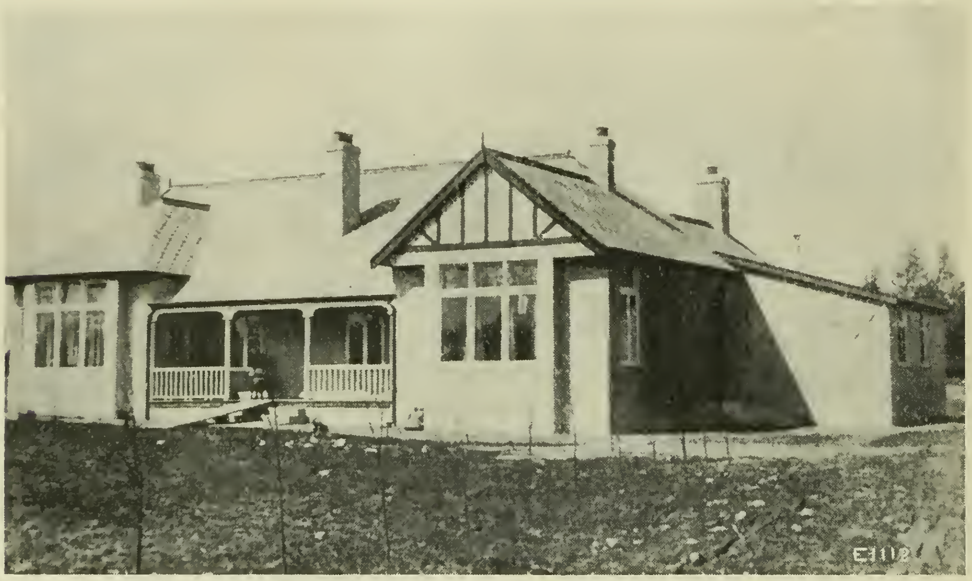


Fig. 6. A Bungalow Roofed and Lined with Asbestos Tiles and Sheets.

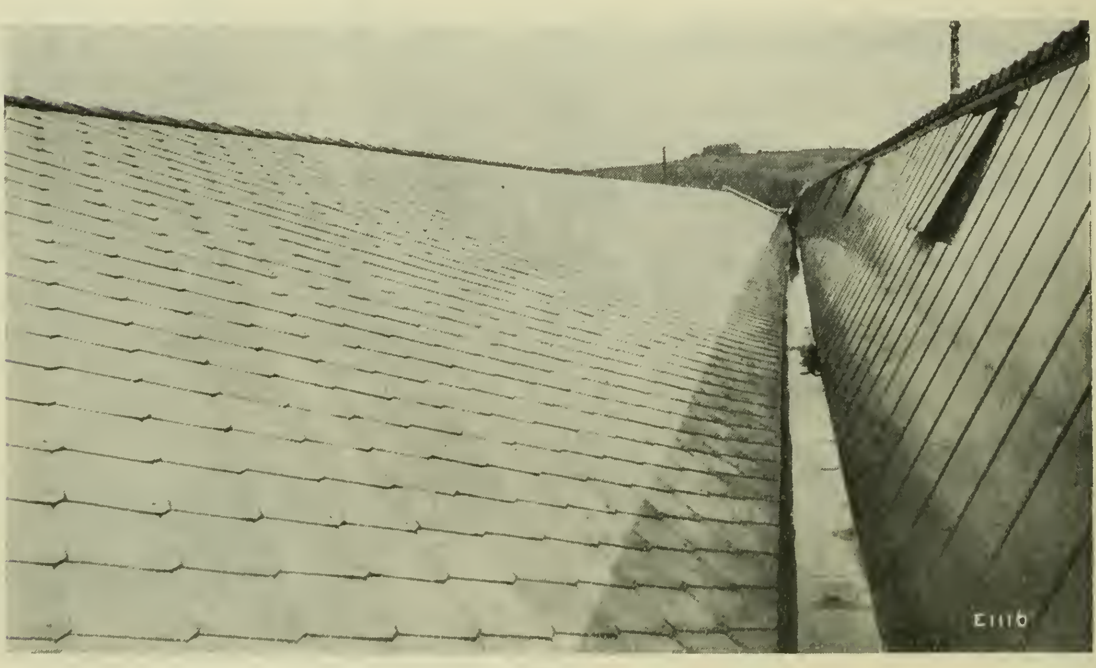


Fig. 7. Asbestos Cement Slates on Factory Roof.

work galvanised driving screws or roofing nails are used, these being spaced at 14-in. centres. The holes are formed in the upstanding corrugations, and asbestos or lead washers should be placed on the outside under the head of the bolt or nail. Special asbestos cement ridging is supplied for use with the ordinary or corrugated tiles, this being either of the plain type, which is attached to the corrugations in such a manner that a space is left to act as a ventilator, or a fitting ridging is used which follows the contour of the tiles to give a weatherproof finish. The ridging is obtainable in lengths from 2 ft. to 3 ft. 8 in., and with 8 in. or 12 in. wings. The corrugated tiles are very pleasing in appearance, as they give an effect which is similar to the old-fashioned "pan tile," much adopted by architects in artistic domestic work, but, unlike the old-fashioned tiles, they can be securely fixed, are weathertight, and very strong.

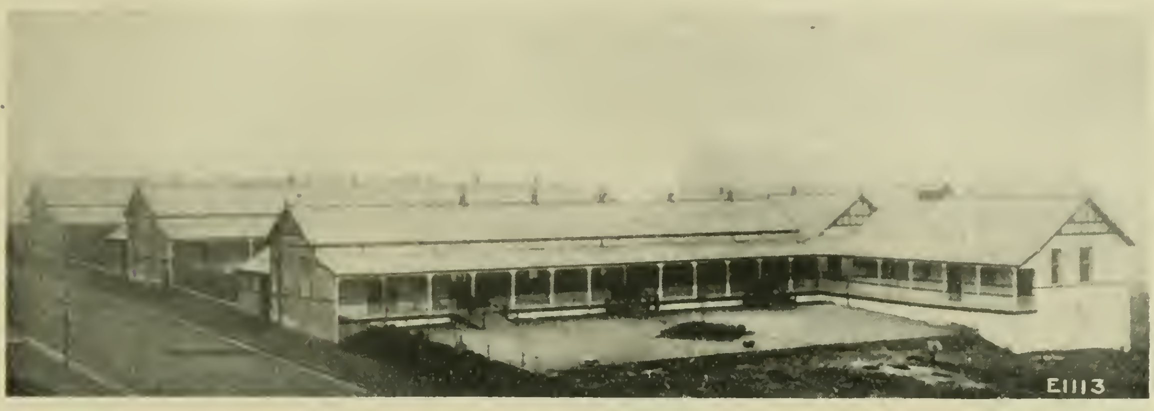


Fig. 8. Open-Air School at Hollybrook, Glasgow.

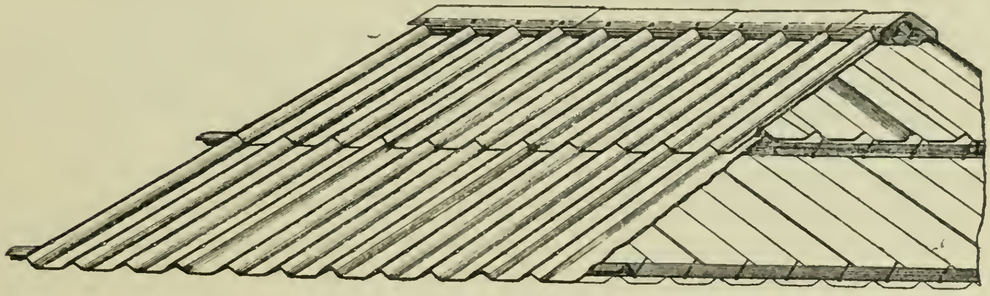


Fig. 9. Corrugated Tiles, showing Method of Fixing.

Various Uses.—There are many and sundry uses to which asbestos cement can be put, in addition to the particular examples given above. As a lining for damp walls the sheets have been extensively used with success, and for fire protection generally it is an excellent material. In the construction of earthquake resisting houses they have been adopted in Central America, Japan, and New Zealand, and owing to the ease with which the material can be transported and handled, it is very suitable for use in remote localities where other materials would present many difficulties. It is frequently used in the formation of ventilation ducts, either alone or in conjunction with timber, and its clean hard surface and the small number of joints render it a suitable material. Its insulating qualities make it valuable for electrical work in connection with casings and washers, and many other minor uses could be mentioned which show that asbestos cement is capable of considerable application in connection with the finishings of a building as well as in the actual construction.

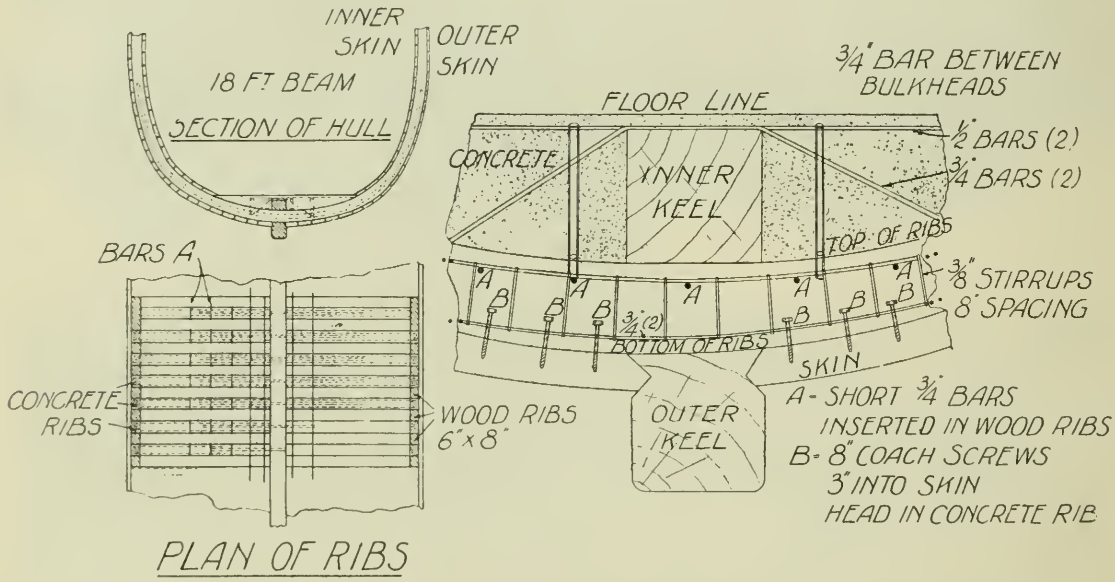
CORRESPONDENCE.

Under this heading we invite correspondence.

To the Editor of Concrete and Constructional Engineering

Dear Sir,—A good deal has been heard of late, and a good many plans published, of reinforced concrete construction as applied to ships and steamers, and it is becoming increasingly evident that this type of craft has come to stay. We think, however, that we have broken new ground in some work which we have just completed, and which consists of repairs to a wooden ship effected by means of armoured concrete.

The circumstances are briefly these : A wooden ship of some 200 tons displacement having been purchased by us for the transport of stone and sand in the River Plate estuary, it was found on placing her under the tip wagons that the impact of some 5 tons of stone falling from a height of 15 ft. caused her to leak badly, and on investigation it was found that the wooden ribs of the vessel were entirely rotted away for some 3 ft. on either side of the keel, and the good state of the wooden skin alone kept the bottom from collapsing. It was judged that the boat in this state could not be docked by means of a slipway, the only means of docking available at the time, as the ribs were not fit to stand the weight.



As the boat was urgently required, it was decided that a good repair might be made by placing new ribs of reinforced concrete in the spaces between the wooden ribs, and the repairs were carried out on these lines, at the same time strengthening the false keel by running two continuous concrete girders parallel to it on either side as shown, tied into the ribs. It will be seen that some of the rib bars were taken up over the false keel so as to tie this to the bottom, and the new concrete ribs were bonded to the wooden ribs by means of short pieces of iron reaching from one rib to another, and seated in holes bored horizontally in the sides of the ribs.

The bond to the skin was effected by means of heavy coach screws which were screwed into the skin planks, the heads being buried in the concrete ribs.

The concrete ribs were taken up sufficiently far to be sure of a good bond with the sound part of the wooden ribs, which were in good condition away from the keel.

The whole of the work was done in a few days while the ship was afloat in a light condition, and the added weight was very little more than the ballast of old chains, etc., which it was customary to use in this craft, and which was, of course, dispensed with. We should be very glad to know if this method of using reinforced concrete has been used by any of your readers ; and may say that the ship now stands quite successfully the rough treatment at the tips without leakage.

Yours faithfully,

Hume Bros.

NOTES FROM THE FOREIGN PRESS.

The following notes abstracted from the Foreign Press may be of interest to our readers.—ED.

DECORATING AND COLOURING WALLS WITH CEMENT.

A WRITER in the Italian journal *Il Cemento* makes the following remarks on this important subject :—

The application of a covering of cement or of ornamental works made of this material to the walls of buildings should only be done in spring or autumn and in damp, cool weather, because it is most difficult in hot weather to secure adequate adhesion as the cement dries too rapidly. If the work must be done during the summer, the walls must be protected in the best possible way from the direct rays of the sun, and kept damp until the colouring has taken well. Particular care must be taken to have the surfaces to be covered with cement absolutely free from dust and dirt; they should be well washed and afterwards damped repeatedly. New cement work does not adhere to dirty surfaces, and those which absorb water too quickly often cause cracks in the new work, and the coating does not acquire that complete hardness and resistance on account of the continual absorption of the water preventing the cement from setting properly.

Walls made of bricks which do not resist frost or which exude acids are not adapted to be covered by cement ; porous walls must be completely protected from dampness ; otherwise the layer of cement would easily detach itself under the action of frost. If the cement contains too much water it is spoilt. It should be prepared as a homogeneous mixture, so as to avoid the cracks which occur with layers of uneven thickness and irregular composition. The cement must not be too soft when used for covering walls exposed to the action of atmospheric agents, as thick coatings under such conditions have a great tendency to crack. The greater the proportion of sand employed in coating without affecting the necessary resistance, the greater its resistance to atmospheric influences. Hence a sufficient quantity of fine sand should be added, so as to obtain a very plastic cement, the plasticity being added, if necessary, by the addition of a little lime. The surface may be finished smooth by the use of iron discs. A trowel should not be used, because the surfaces so finished are uneven in thickness, are often too thick and are more sensitive to the action of frost, and therefore to cracks. To cover a cement surface satisfactorily with oil colours the first condition is that the cement must be quite dry and fully set. Oil colours applied to a fresh surface are not durable and resistant, because the alkali and the hydrate of lime in the cement decompose the oil. When interior walls are to be covered they must be frequently watered until the complete setting of the cement is assured ; they must afterwards be dried before applying the oil colour. It is sometimes desirable, if the coating colour has to be applied quickly, to wash the cement repeatedly with very dilute sulphuric acid—*e.g.*, one part of commercial concentrated sulphuric acid to 100 parts of water. This solution transforms the alkali and lime into inactive sulphur compounds. Alternatively, the well-known fluorides or fluates, especially fluoride of magnesium, may be employed, as they convert the lime into inert fluosilicic acid, which has the further advantage of increasing the density and hardness of cement coating. The treatment with a fluoride (fluate) is as follows : The cement surface must be sufficiently dry. Then fluoride of magnesium is mixed with 10 times its measure of water and applied with a paint-brush. After 20 to 24 hours the operation must be repeated with a solution of double strength. Two or three hours after the second coating has been applied the cement will be ready. It may be tested by applying the tongue to see if it has an acid flavour ; this indicates that a sufficiency of fluate has been used. Alternatively, a damp piece of blue litmus paper should be pressed with a cork against the fluoridised surface. If the treatment has been sufficient the paper turns red. Otherwise the treatment must be repeated until this result is obtained. Afterwards the surface must be thoroughly washed, dried and then covered with the oil colour.

ACCIDENT TO A CONCRETE FLOOR.

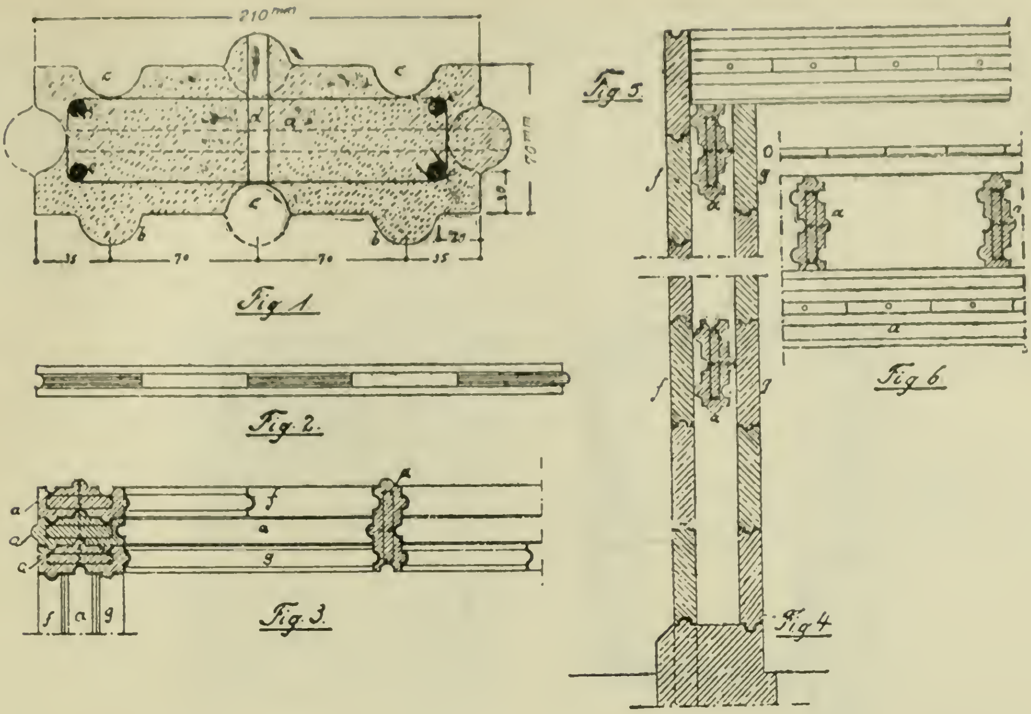
A steam-driven saw-mill built of reinforced concrete and measuring 108 ft. by 41 ft. with the first floor 9 ft. above the ground and a reinforced concrete roof 13 ft. higher. The first floor—which was carried on two beams, which were placed so as to divide the floor into four equal areas, each of reinforced concrete 4¾ in. thick—was intended for storing dried wood for furniture, the estimated load being only 10 lb. per sq. ft. The floor was built as lightly as the local regulations permitted—viz., for a load of 11 lb. per sq. ft., which is extraordinarily light for a storeroom 13 ft. high. A small runway was erected later ; the floor was overloaded and would have fallen but for being promptly propped up. Investigation showed that one part of the floor was loaded with 60 lb. per sq. ft. and another 106 lb. per sq. ft., and it was concluded that the damaged portion had been loaded to about eight times the calculated safe load. The building was badly designed, the bending moments having been calculated for dead instead of live loads and, therefore, about 28 per cent. too low. The spans were specified as 12 ft. 8 in., but at the fractured portion the span was 13 ft. 3 in. So far as they could be seen the reinforcing bars did not extend far enough, and whilst their ends were hooked they were too flat. They were barely 1 in. in diameter, whereas they should have been 1¼ in. The crossed reinforcement was quite insufficient. The failure of this building shows that the most careful and accurate specifications are useless unless they are properly followed by the builder. The official examiner made a suggestion which is worth adopting widely—viz., that all upper storerooms should have a mark on the walls showing the maximum height to which the floor may be loaded with safety. Such a precaution would prevent much of the present serious overloading.—*Beton u. Eisen.*

REINFORCED CONCRETE FOR SMALL DWELLINGS.

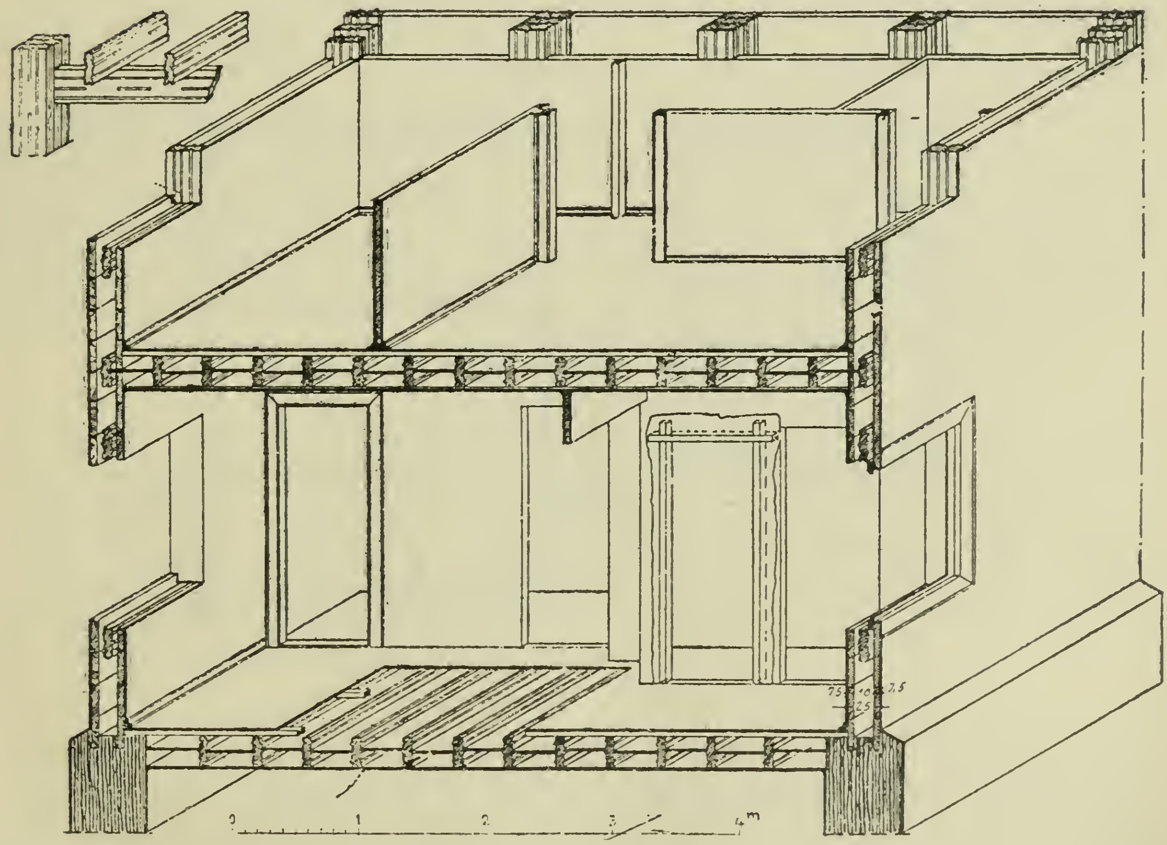
The accompany illustrations may be of interest as showing what is being done in enemy countries to solve the problem of the small dwelling. The illustrations are taken from the *Deutsche Bauzeitung*, of August 17th, from an article by Dr. Werner Scheibe, Government architect of Klotzsche, near Dresden, and refer to a special system of construction known as the " Kilp " system. The author describes the system as follows :—

The unit building block is 210 mm. long by 70 mm. in cross section and of such a length that it can be carried by two men. It is reinforced by four thin rods wired together at intervals. One edge has a semi-circular groove and the other a rounded projection, while one flat side has two projecting ribs and one groove to correspond with two grooves and one rib upon the other face.

The piers of the building are constructed of such blocks placed vertically ; three, for example, being bolted together, while the spaces between the piers are formed by the same type of blocks laid horizontally with an air space of 10 cm. between the inside and outside skin. Where window openings are required a standard slab is inserted in the air space. The floor joists, partitions and roof are constructed of similar standard slabs, and it is stated that spans up to 6 m. wide can be adopted. The construction is so simple that unskilled labour and women can be employed under the direction of one skilled man. As soon as the plastering and fixing of windows and doors is completed the houses are ready for occupation. The cost

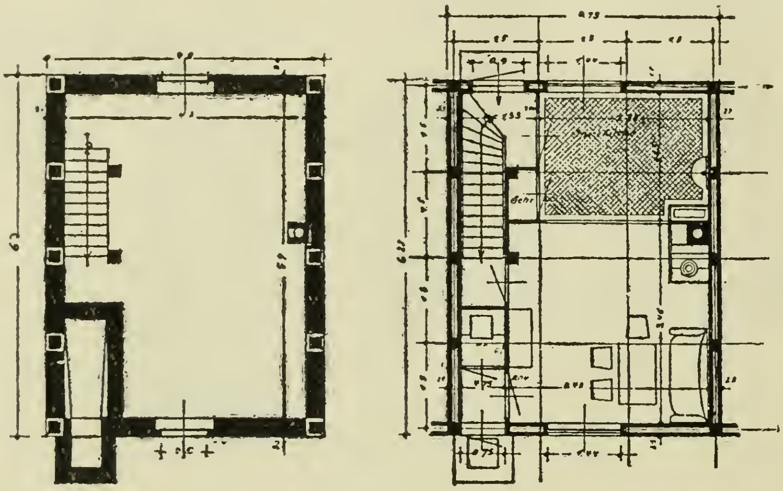


Details of Reinforced Concrete Work.



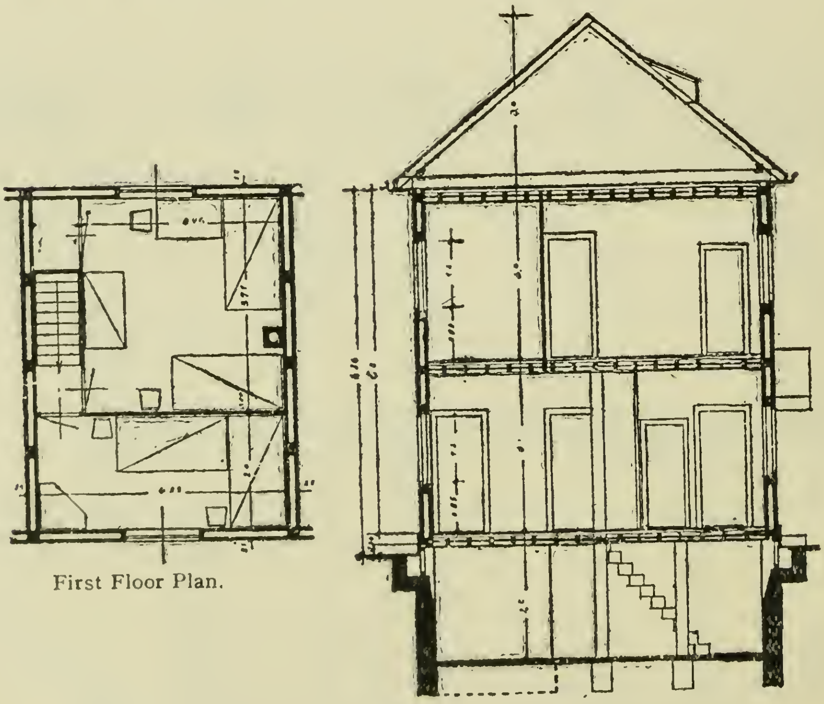
Isometric View of the Structure.

per sq. metre of wall surface, inclusive of floor joist erection, is stated to be Mk.12-15 (say, 1·1 to 1·4 shillings per sq. ft. of surface). The cost per cu. metre of the finished house is about Mk.25-30 (say, 8·4 to 10d. per cu. ft.). The cost of a house of which an illustration is given was £275 to £300. This house is 4·25 m. wide by 5·75 m. front to back inside, forming one of a row, with cellars 2 m. and ground and first floor 3 m. high in the clear ; the roof is of the ridge type, for use as a store. The accommodation is a kitchen living-room and scullery on the ground floor, and two bedrooms on the first floor, in one of which are shown two full-size beds and in the other two full-size beds and a cot. The author states that such a house can be built in 1 to $1\frac{1}{2}$ days of actual time if a row of houses are being constructed at the same time. He is of opinion that this is a very promising system of construction, and work is already in progress by the Small Dwellings Co., of Bamberg.



Plan of Cellars.

Ground Floor Plan.

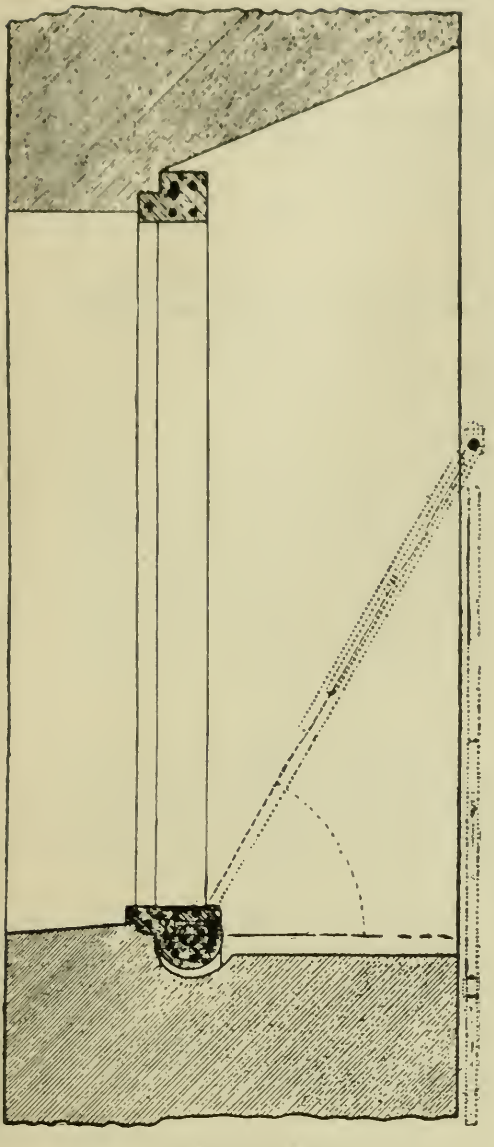


First Floor Plan.

Section.

Plans and Section.

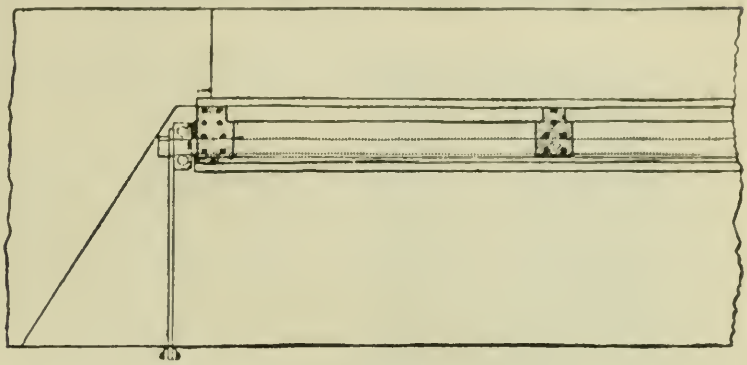
A REINFORCED CONCRETE WINDOW.



Vertical Section.

A window of reinforced concrete, recently designed by an Italian architect, is 4 ft. 8 in. wide and 2 ft. 4 in. high, divided into three parts, each 1 ft. 4 in. by 2 ft. 3 in.

The arrangement of the ⅛-in. reinforcing rods is clearly shown in the sections, which also illustrates the semi-cylindrical base on which the movable part of the window rotates. The window can rotate through an angle of 60° ; it is opened or shut to any desired extent by means of a knee-jointed lever of the customary type.



Horizontal Section.

The concrete is a 1 : 3 mixture of cement and sand, the weight of the concrete portion of the window being 109 lb., and that of the reinforcement 13 lb.

The cost of construction is about 12s., of which sum the reinforcement costs 2s. 2d., the concrete 2s. 2d., labour 4s. 2d., and the iron operating lever 3s. 6d. This pattern of window, therefore, costs less than a wooden one of similar type, and is much more durable.—*Il Cemento.*

CONCRETE PILES.

In the *Deutsche Bauzeitung* of September 11th, 1918, a special type of concrete pile, known as " The Mast," is described. The pile forms the subject of a patent, and it is said that it is gives particular protection against the deleterious acids of bogs. It consists in the use of a thin sheet iron cylinder, with the lower end folded to a point, and shod with a pyramidal end. This is driven down through the bog into solid ground, and afterwards filled with concrete. It is claimed that this form of pile will carry specially heavy weights.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Manchester Association of Engineers.—A Paper on the Development of Reinforced Concrete was read before the Manchester Association of Engineers on December 14th by Mr. B. Taylor, A.M.I.Mech.E. In the course of his address the author stated that the rate of development of reinforced concrete from its early commencement as a building material—that is, after its merits had been discovered—could perhaps be better represented by the tangent curve ; progress of development being at first very slow and increasing in greater and greater proportion as examples and tests demonstrated its utility, until it is now recognised as one of the standard and best materials for various classes of construction.

It is pleasing to state that practically all the earlier objections that have been made in reference to concrete and reinforced concrete, have been or are being removed, and that reinforced concrete has now become recognised and accepted by responsible people as a standard form of construction. The Government departments have adopted it for various important works and encouraged others to use it, which has given it a great impetus.

As experience has been gained in simpler forms of construction with satisfactory results, it has encouraged people to go a stage further and do more complicated work and so on, until there is, at the present day, quite an extensive range of work in which it has been satisfactorily used.

After dealing with various technical points relating to concrete and reinforced concrete, the author showed a number of slides illustrative of various types of reinforced concrete structures recently carried out.

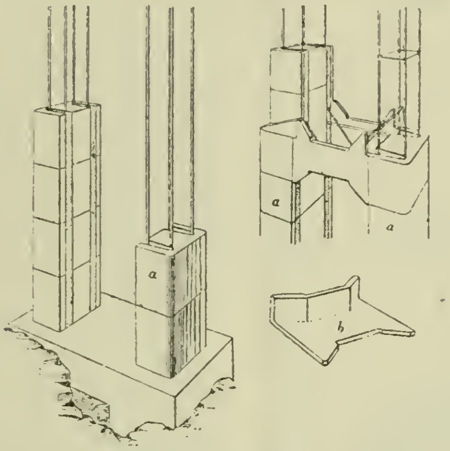
Reinforced Concrete in North Borneo.—It is interesting to note that the authorities in British North Borneo are fully alive to the value of reinforced concrete as a constructional material, and we learn that its employment is quite common. For a long time the Public Works Department have been making and using concrete drain pipes, fence posts, piles, safes, etc., and the uses to which this material may be applied are being constantly extended.

Concrete and Sea Water.—A patent has been granted in the United States for a process of erecting concrete structures, which are claimed to be immune to the chemical action of sea water. Briefly stated, the process consists in using flexible sheets of celluloid or other material, inside the exterior forms. When celluloid is used it not only prevents the absorption by the forms of water from the concrete mass, but produces a smooth highly enamelled concrete surface especially desirable for boats. The desired mix is prepared and poured, but not tamped from the top nor spaded. Instead, the method is to tap or hammer the exterior of one or both of the form walls at and just below the level of the concrete as it is poured into the forms. The result is a quaking and settling of the concrete mass. The superior gravity of the concrete, under this hammering, causes its particles to settle and produce a compact mass, expelling air and water which otherwise would leave pockets and voids. The tapping and hammering may be conducted with pneumatic or hydraulic hammers. After the curing process is completed, the forms and celluloid linings are removed. An outer skin of superior density is thus formed which will oxidise to lime carbonate, making a surface that will resist the action of sea water; and the interior mass, from which the air has been expelled, assumes a crystalline form, without voids, and is protected by the lime carbonate exterior coating from attack chemically by the sea water. The reinforcing steel is put in position after the outer form wall with its celluloid lining has been erected.

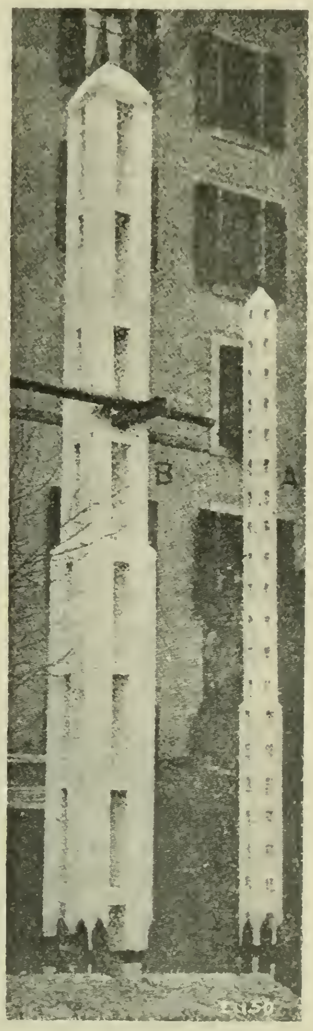
Fence Posts.—An American experimental station gives the average life of fence posts as follows: Concrete, 48 years; steel, 30 years; Thuja gigantea, 20½ years; oak, 15⅓ years; pine, 11¼ years; ash, 8½ years, with the pertinent remark that the first cost of a post or a tree is not the only thing to be considered, but its duration of life, owing to its resistance to decay.

Telegraph Poles and Other Standards.—The construction of telegraph poles, cable standards and pylons of concrete has many obvious advantages over those of wood, especially now that the latter is scarce.

A form of structure which is noteworthy is shown in *Figs.* 1 and 2, in which the units are blocks 10 in. high and weighing about 22 lb. each. The reinforcing bars are first erected and the concrete units, *a*, are then placed round them and fixed by means of fine concrete. Changes in section are effected by means of suitable blocks. A telegraph pole measuring 10 in. by 10 in. at the base and 8 in. by 8 in. from the middle to the top, composed of blocks 10 in. high, reinforced with rods ½ in., was tested by a horizontal tensile force, applied through a pulley, and cracked within ten minutes when the load was 4,460 lb., which is about 300 per cent. of the normal force the pole is intended to resist. A standard for a high tension cable measured 2 ft. 4 in. by 2 ft. 8 in. at the base, consisting of four pillars 11 in. by 12 in., 1 ft. 2 in. by 2 ft. 3 in. at 19 ft. from the base, and there consisted of four pillars each 10 in. square. A progressive increasing tensile force was applied to the top of the standard, and when this force reached 3,520 lb. the foundation gave way and stopped the test. This force was 209 per cent. of that which the standard was designed to resist.



METHOD OF CONSTRUCTING THE POLES.



VIEW OF POLES SUBMITTED TO TEST.

A microscopic crack appeared under a force of 2,684 lb., or 160 per cent. of the normal. These tests show that these standards behave as true monoliths, there being no sign whatever of the reinforcement being damaged in any way in the test.

The great advantage of using a limited number of unit blocks is shown by the fact that four different sizes and shapes of blocks enable 44 different patterns of standard to be erected.

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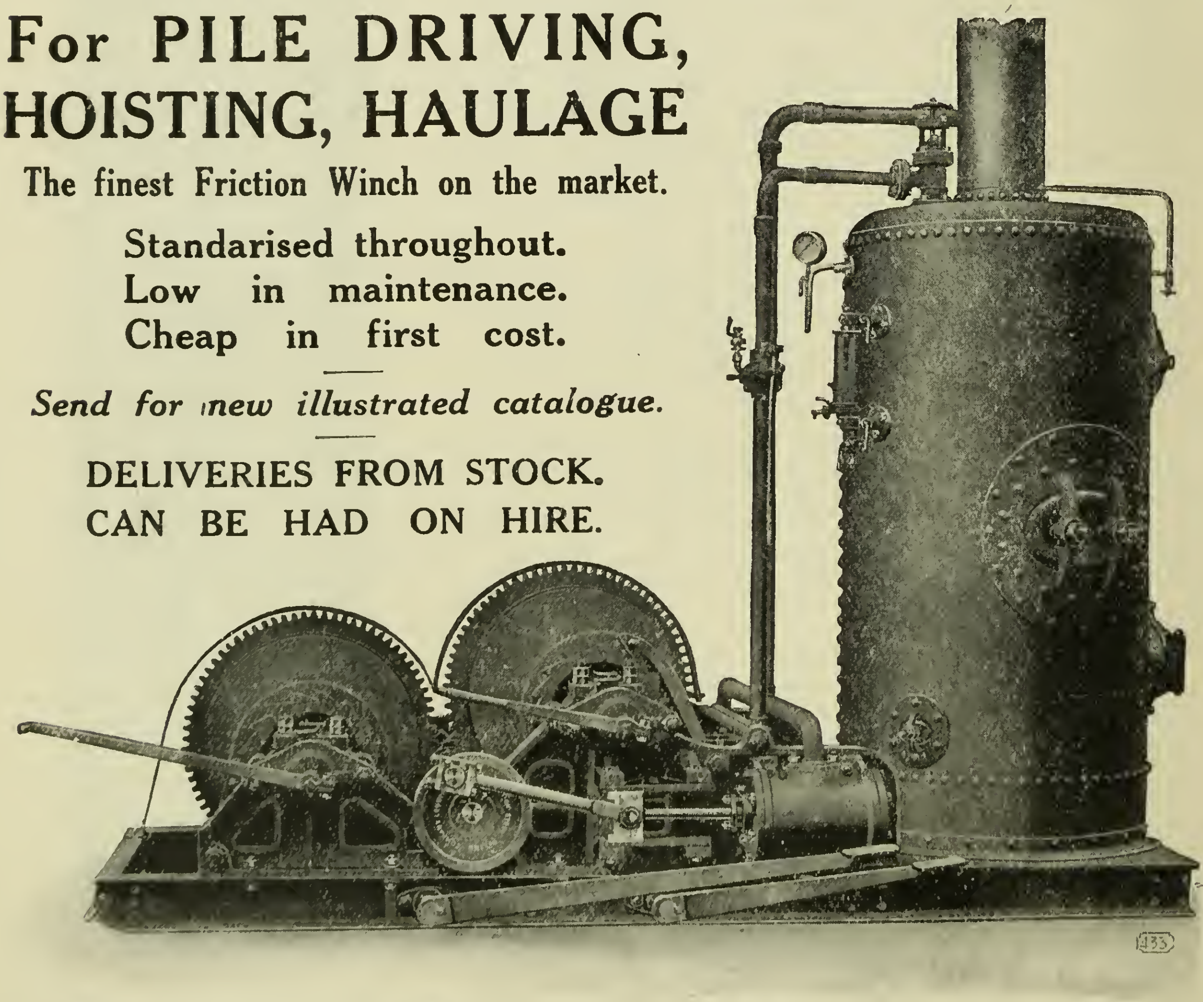


DOCK HOUSE, *Billiter Street*, LONDON, E.C.

The units are sufficiently small to be readily transported and enable the standards to be erected easily and rapidly without any special plant being necessary.—*Le Genie Civil.*

Reinforced Concrete Mains in Extension Scheme.—In his report covering the twelve months ended March last, Mr. W. Ingham, M.Inst.C.E., M.I.Mech.E., chief engineer to the Rand Water Board, furnishes some particulars of a scheme by which it is proposed to improve the water supply of the East Rand.

The scheme provides for laying a 24-in. pipe line, nearly 7 miles in length, from the Village Pumping Station, Johannesburg, to a new open reservoir, having a capacity of 2½ million gallons, which will be erected on Signal Hill, about 1 mile north of the present Simmer and Jack reservoir, Germiston, at an elevation of 5,822 ft. above sea level. From this reservoir an 18-in. pipe, about 1 mile in length, will be laid to connect, near the Simmer and Jack reservoir, with the present 16-in. trunk main leading to the East Rand.

It is also proposed to erect a new open reservoir having a capacity of 2½ million gallons on the hill about 2½ miles north of Benoni, at an elevation of 5,580 ft. above sea level. A new main, 12 in. in diameter and nearly 3 miles in length, will be laid between Benoni and the latter reservoir, and will act as an outlet as well as an inlet pipe. Automatic valves will be fixed in the pipe line in the neighbourhood of both reservoirs, so that the water will pass direct into the distributory mains when the reservoirs are full. The area served by the Benoni Reservoir will cover the whole of the East Rand. This reservoir will stand about 160 ft. above the floor level of the Benoni Town Hall. The water pumped into the Signal Hill Reservoir will gravitate to the Benoni reservoir, or, if that reservoir is full, will supply the East Rand direct through the present trunk mains.

The present trunk main between the Simmer and Jack reservoir and the Benoni township, which consists of 16-in. and 14-in pipes, will be utilised for delivering the water to the East Rand, but eventually it will be necessary to lay a second main in this section.

Owing to the difficulty of obtaining steel and cast-iron pipes for this scheme, it has been necessary to consider an offer from the Hume Pipe Company for supplying reinforced concrete pipes. Before the Board decided to accept this offer, inquiries were made from well-known engineers in Australia and Tasmania as to the desirability of utilising the Hume pipe to withstand a working head of about 300 ft., and the replies were entirely satisfactiory.

The total cost of the scheme will be £75,315, of which about £47,000 will be for reinforced concrete pipes.

Concrete Auxiliary Fishing Schooner.—A 120-ton reinforced concrete auxiliary oil-engined fishing schooner, the first craft of its kind, is under construction by the American Concrete Pipe and Shipbuilding Co., at Bryn Mawr, on the shore of Lake Washington. This vessel will be used on the North Pacific halibut banks.—*Motor Boat.*

Cardiff's Water Supply.—Steel Reinforced Concrete Pipes Proposed for New Main.—The Cardiff Waterworks Committee recently discussed the question of the Taff Fawr conduit second pipe line. Mr. C. H. Priestley, the water engineer, reported as to the type of pipes to be used in the new main. Taking into account the nature of the district through which the pipes would pass, and the consequent danger from subsidence in the vicinity of collieries, etc., it was recommended that steel reinforced concrete pipes, which were capable of standing great strain, should be used. The total cost of such pipes over the 30 miles of laying would be £309,089.

PUBLICATIONS RECEIVED.

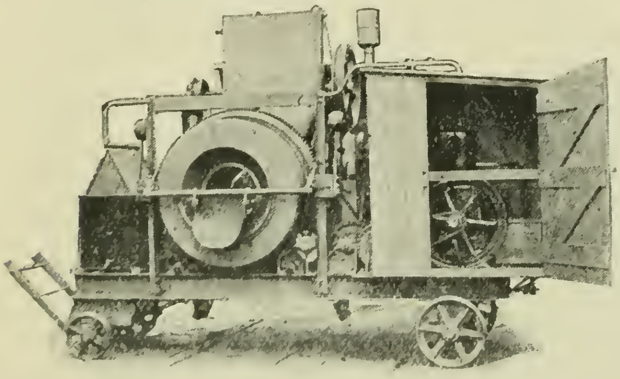
The Housing Problem.—We have received from Messrs. Winget, Ltd., a copy of their illustrated pamphlet dealing with their system of concrete blocks and slabs on the continuous cavity system for small houses, cottages, hutments and other small structures. A number of very good illustrations are included in the booklet of cottages and housing schemes, and the method of making the blocks is also shown and described. Copies of this publication can be obtained from Messrs. Winget, Ltd., 25, Victoria Street, London, S.W.1.

Reconstruction Problems.—The Ministry of Reconstruction have issued their pamphlet No. 5 dealing with reconstruction questions entitled, "New Fields for British Engineering." Price 2d.

TRADE NOTE.

A Tunnel Rendered Waterproof by the Aid of Metalo Liquid.—Those who are acquainted with the ancient town of Chatham will probably remember the position of "The Picture House," which is situated a very short distance from the Medway river. Some two years ago the proprietors of this picture house, for the convenience of their patrons, had a tunnel made under the Empire Theatre in order to get to the Picture House, a distance of some 130 ft. It was necessary to build this tunnel 8 ft. below the water level, and only 6 ft. away from the river bank. The walls of the tunnel were built in concrete, 2 ft. 3 in. in thickness, but it is stated that the great pressure of the water from the exterior proved too much for the water resisting capacity of the concrete used, and in a few days water had penetrated to the depth of 8 ft. throughout the length of the tunnel, thus rendering it not only useless, but a danger to the superimposed structure.

The services of a well-known London firm were called in, pumps were set in motion and when the water had been reduced as far as possible, a rendering of 1½ in. thickness of metallic mastic was placed on the walls, and a 2-in. rendering on the floors was adopted. We are informed that immediately the whole of the interior had been covered with the rendering mentioned above, moisture no longer percolated, and the passage became a dry footway, through which one could pass in comfort. This work was completed some two years ago, and the architect states that the tunnel is still in the same satisfactory condition that it was when the work was finished.



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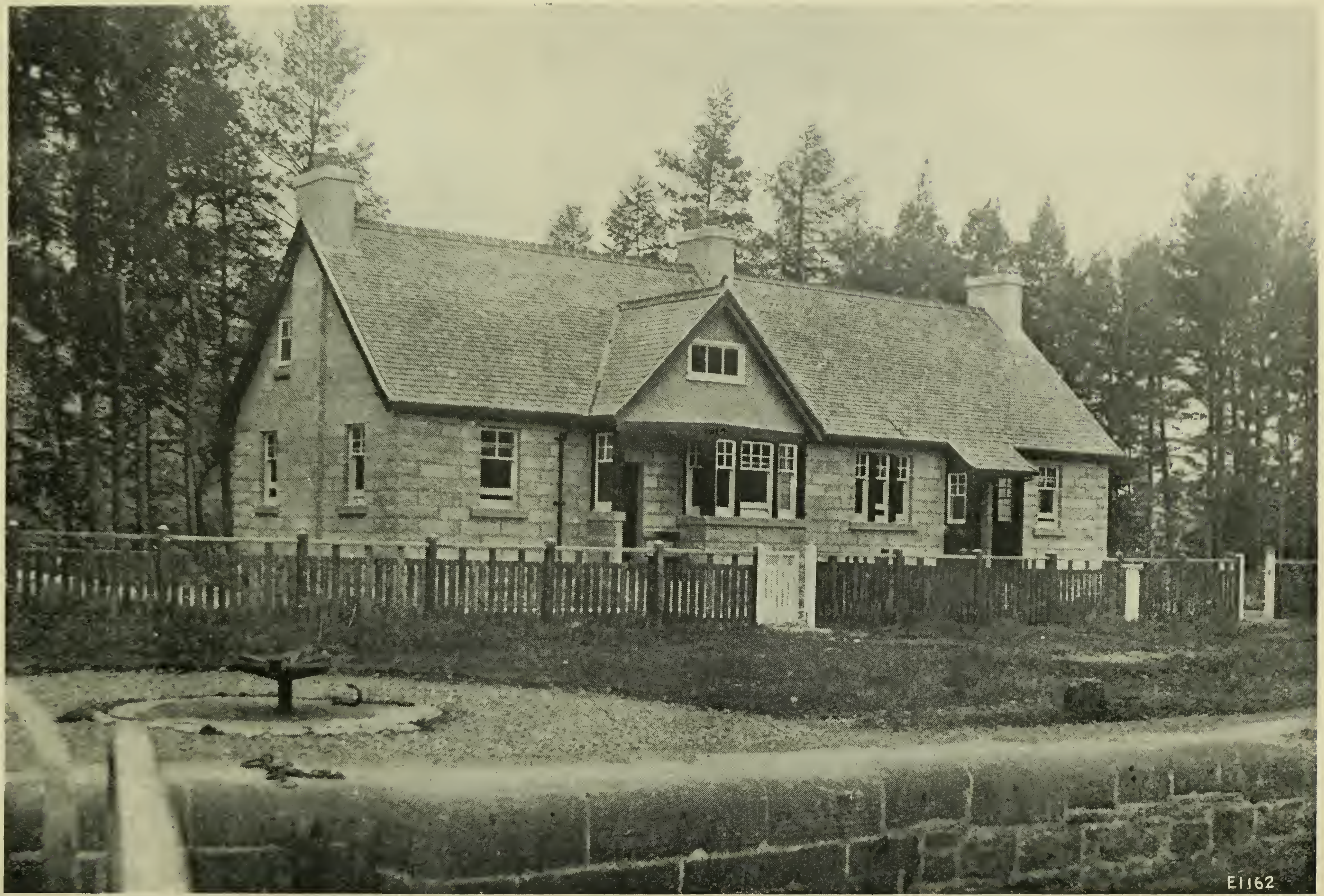


Concrete Cottages in the Scottish Highlands.
(*For description see page 81.*)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV., No. 2. LONDON, FEBRUARY, 1919.

EDITORIAL NOTES.

THE SHORTAGE OF BUILDING MATERIALS.

MUCH is being said about the shortage of bricks in regard to the housing problems of the current year. We do not see how this can interfere with immediate progress, as concrete, and particularly concrete blocks, would fill the gap and would more than fill it economically and with much saving of transportation. In the early days of concrete construction the conservative and the prejudiced desired to make it known that the concrete cottage meant a cottage without artistic effect. This argument no longer holds good, as anybody can see who will take the trouble to travel to Chepstow and inspect the more modern form of concrete block construction, as admirably practised under the supervision of Mr. Wm. Dunn, F.R.I.B.A., in that area.

Those who are prejudiced against the use of concrete for cottage construction do not appear to realise that a brick cottage is all too frequently the acme of ugliness, owing to bad design and incompetent workmanship. And whilst we fully realise that a brick cottage well designed and executed may be made eminently artistic, we know that a concrete cottage can be made quite as artistic and in most cases for far less money.

It cannot be sufficiently impressed upon the estate owner and controlling authority that, in these times—apart from any other question—the great advantage of using concrete for housing schemes is that the essential aggregates are nearly always on the spot and require little or no transportation, the carriage being limited to the comparatively small proportion of cement required for any one concrete cottage.

And whilst we are discussing this matter, it should again be impressed upon those who have control of these matters that, whilst it is not possible to overcome the difficulty of obtaining timber, during the current season or the next, entirely by the use of concrete as a substitute, there are quite a number of essential features in housing construction which can be quite effectively and more economically produced in concrete, and which will require less expense in maintenance and replacing than timber as time goes on.

Seeing the great demand for cottage work, what is required is to form a small practical committee of five men, thoroughly conversant with the use of concrete, to set out in the simplest and tersest form possible, with illustrations, a series of practical recommendations as to how the most handy of materials, namely, local aggregate, can be turned into cottages by the use of a small proportion of cement. And it would not be inappropriate if a Government Committee were set up for this purpose, say—under the auspices of the Walter Tudor Committee with a representative from that body.

CONCRETE ROADS.

This journal has, from time to time, presented valuable examples of concrete road construction. Many millions will have to be spent in road repairs and improvements on account of the damage caused by military traffic during the past four years. Surely the time has now come to follow the very excellent example of the United States by putting down concrete roads, suitably reinforced, where there is a large amount of heavy traffic to be expected, and, in any event, on difficult and tricky ground and on heavy traffic cross-roads. The first cost of such roads is, of course, higher than what we are used to, but the maintenance charges are so small that we should be amply repaid for the original capital outlay.

We would remind those who are considering the road problem that it must be borne in mind that it will no longer be a matter of the traffic of the touring car and of the small motor van that has to be catered for on our main country roads, but practically an entire motor traffic, both for passengers and goods, of the average three-ton type, fitted with solid rubber double tyres, and for traffic of this description the concrete road meets the case.

There is only one point to which we would like to call special attention. Where concrete roads are going to be laid down, it is advisable to incur the slight additional expenditure, where necessary, of relaying electric mains, water mains, and the like well to the side of the road, if possible just at the edge of the concrete surface, so that the concrete surface need not be disturbed for repairs and replacements. This is a matter that is all too frequently overlooked.

Whilst dealing with the subject of roads, it would surely be well to do away with many of the timber telegraph posts, signposts, and mileage marks which still exist on so many highways and which are now due for renewal, and to replace these by permanent concrete posts and marks, of which the railway companies have had such excellent experience.

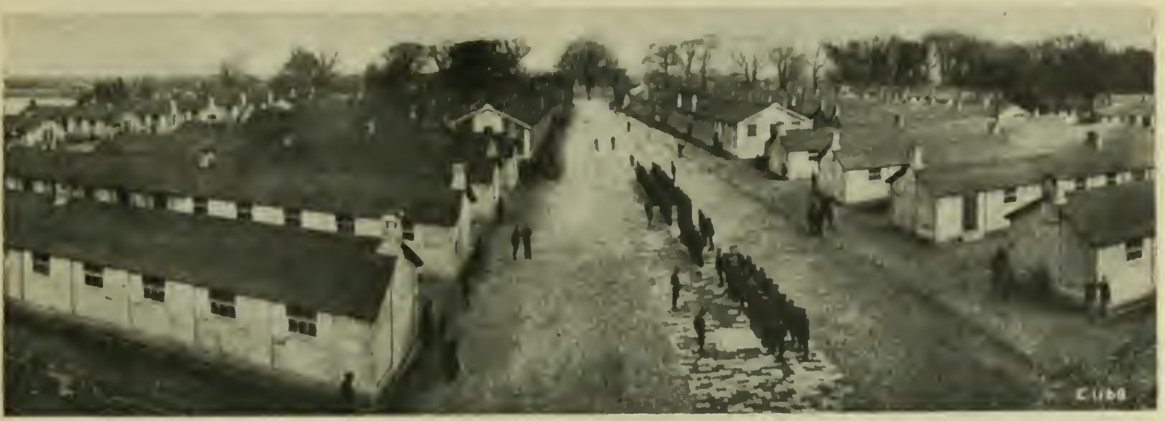


Fig. 1. A General View of a Portion of Richborough Camp.

THE MYSTERY PORT OF RICHBOROUGH.

The following article, whilst being a short general description of the development of Richborough, also indicates briefly the varied uses to which concrete was put in this connection.—ED.

THE definitions of war range from " organised destruction " to " a necessary part of the development of every progressive nation " and between these two extremes, authors looking each from a different point of view have glorified or cursed the warlike spirit which is ever present in the human race.

What influence the war, now ending, will have on the future of Europe it is impossible at present to foretell, but a quickening of organised scientific commercial enterprise will certainly be part of the aftermath, and the great " Mystery " port of Richborough will probably be the nucleus of a great Channel port for the transport of goods from this country to France and Belgium.

For months past rumours and hints of " Mystery " ships, aeroplanes, tanks, and districts have been common, and although the enemy may through their spies have become aware of the growth of Richborough, and on one occasion dropped a bomb in the immediate vicinity, no serious hostile damage was done, nor have any casualties occurred from enemy action.

The site of the port is the flat, marshy ground between Sandwich and Pegwell Bay, where, till 1915, a ruined Roman castle, two or three shepherds' huts, and a few sheep grazing on the rough grass were the only indications of civilisation; for the stillness of the marshes was broken only by the call of the wild fowl, and through this rough marshland the River Stour slowly wound its way into Pegwell Bay. In 1916, however, the growing transport of the Army and the inconvenience of carrying on the work of the military in the naval port of Dover made it desirable that a new base should be created, and after an exhaustive enquiry into the merits of several districts the present site was chosen. Its position, behind the shelter of the Goodwin Sands, whilst allowing for the development of ferry and barge traffic from England to France, made it practically immune from naval attack, and its low-lying situation and the consequent ground-fog, which is inseparable from the district, greatly helped it to outwit air raiders.

The beginning of the scheme arose from the expansion of the Inland Water Transport Section of the Royal Engineers which was first employed on the French

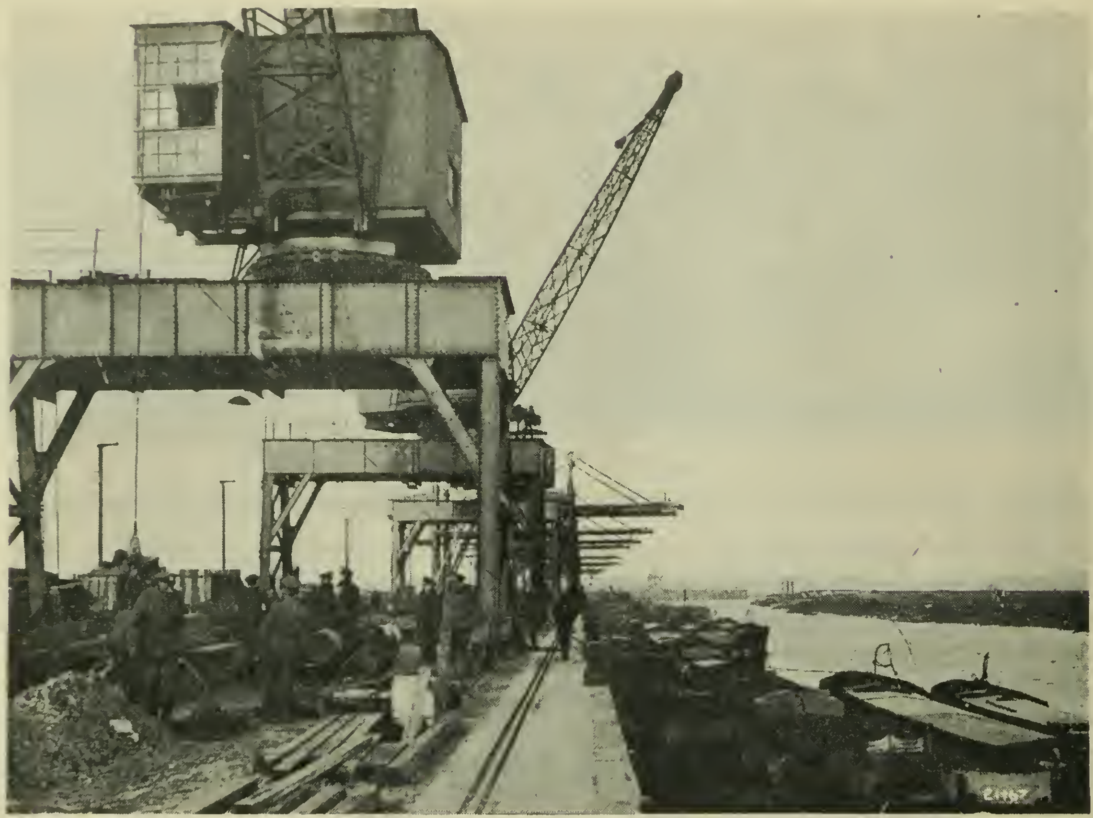


Fig. 2. The Quay at Richborough.

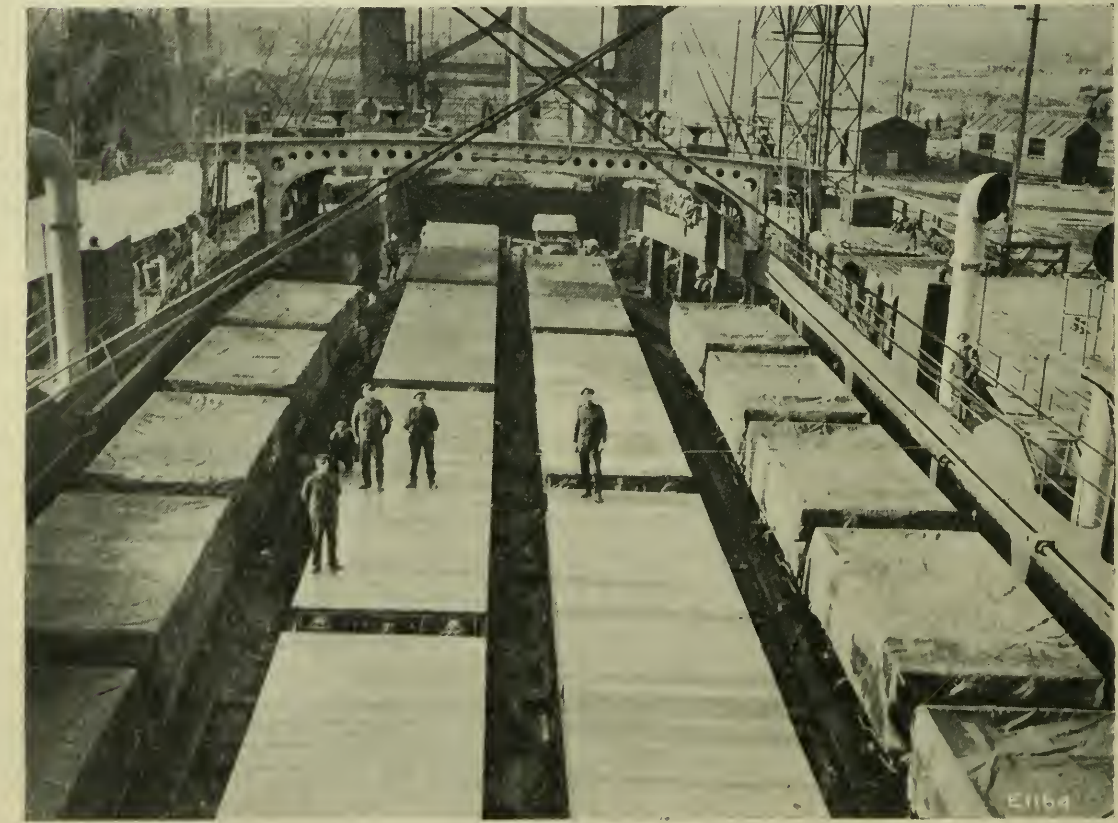


Fig. 3. The Well of the Ferry: a Train aboard.

By courtesy of "The Graphic."]

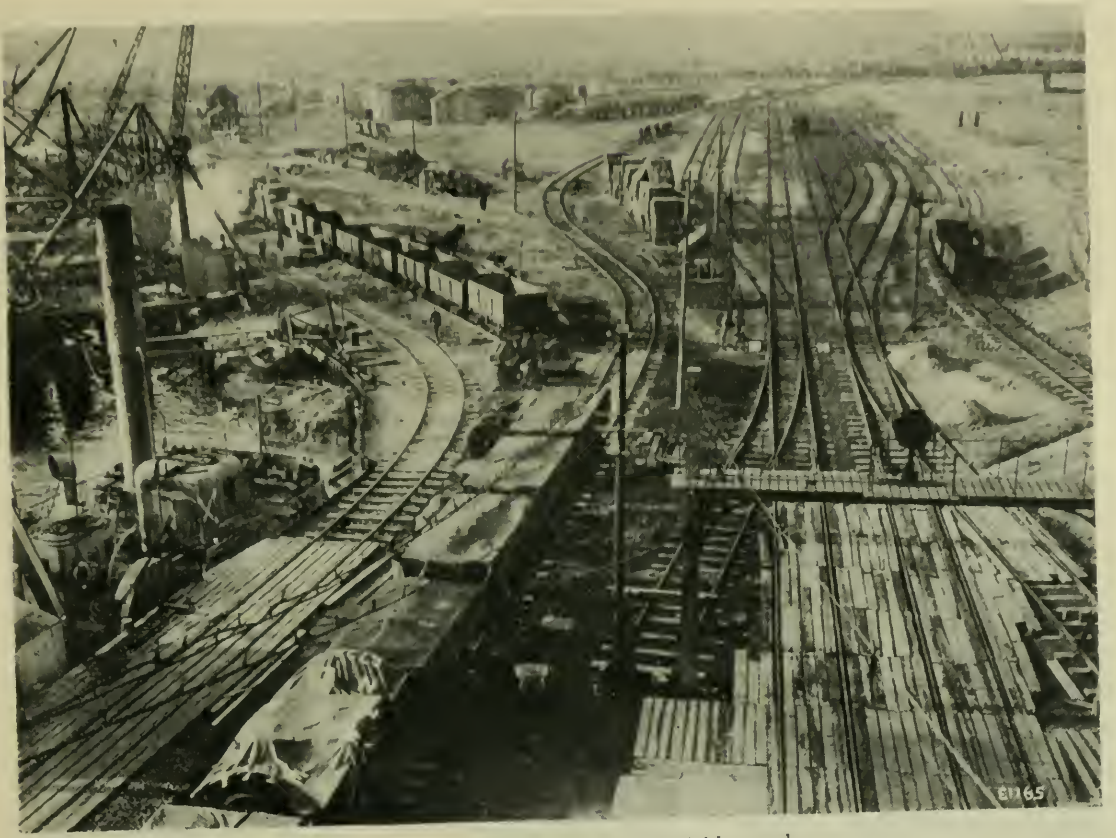


Fig. 4. A Network of Railways at Richborough.

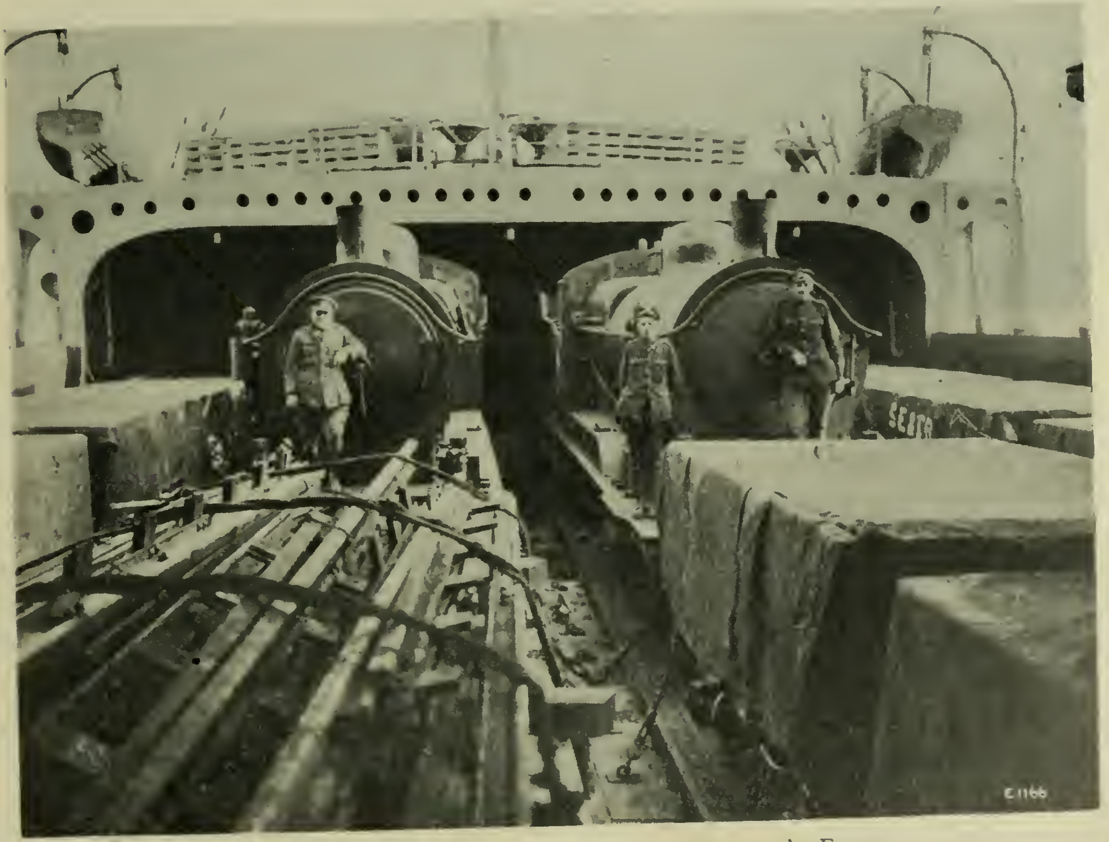


Fig. 5. View showing Engines with heavy loads on the Ferry.

By courtesy of "The Graphic."]

and Belgian canals on the Western Front, and which began on a very small scale. As, however, the Army increased, and the weight of transport became so great as almost to cripple the resources of the French ports, a cross-Channel barge service was commenced, and 200-ton barges were towed across the Channel and taken direct along the French canals to the various supply depots.

The great saving of time and labour caused by this innovation will probably be better understood when the full tale of the pressure on the railways and the vital need for more and more shipping comes to be told, but the following figures, which are up to the end of October, 1918, are of interest :—

Weight of material carried to Continent by barge and ferry services, 1,260,000 tons. Weight of salvage brought back, 160,000 tons.

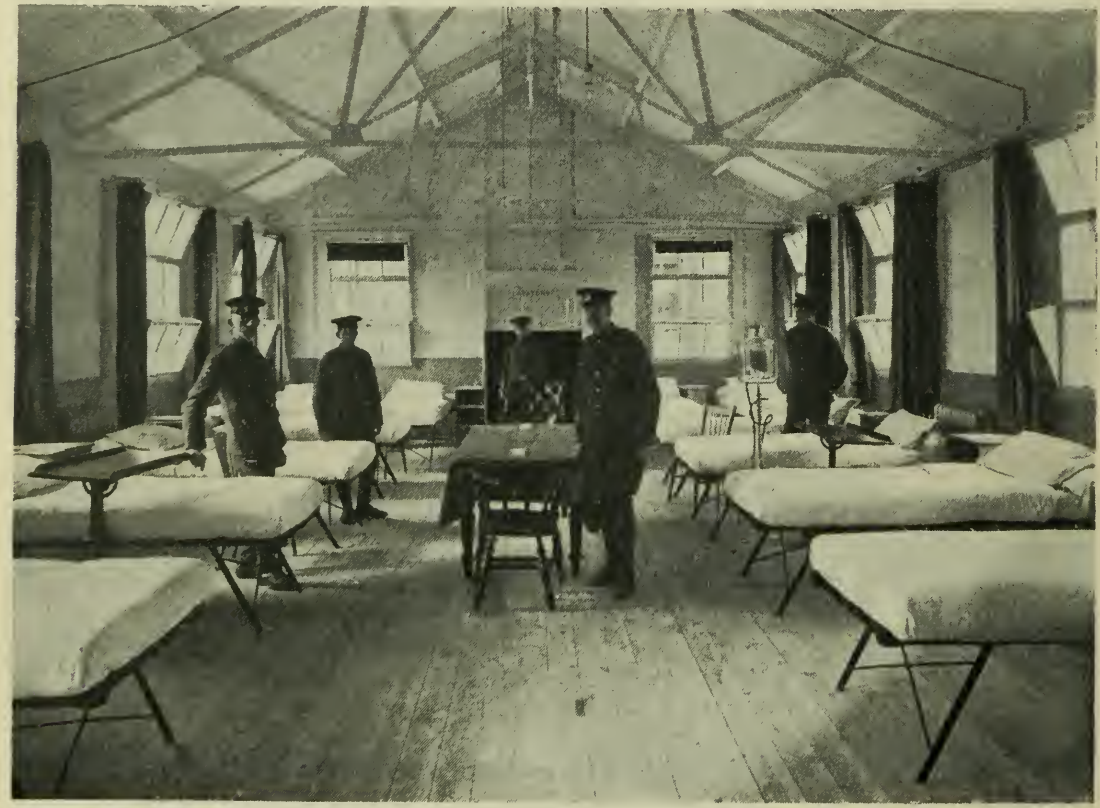


Fig. 6. Interior of Hospital at Richborough Camp.

Included in the above are : 160 locomotives, 6,200 W.D. railway trucks, 658 tanks, and 4 14-in. guns on railway mountings, each weighing 302 tons.

When the works were first mooted two schemes were considered by the Government :—1. The construction of a new wharf with railway sidings and supply depots. 2. The extension of an existing wharf on the banks of the Stour.

The first scheme was decided upon, work was commenced in the summer of 1916, and such rapid progress was made that by December, 1916, a regular cross-Channel service was in being.

The wharf is constructed with steel sheet piling with a capping of mass concrete, and on the surface of the wharf tracks are laid for the movement of the giant electric travelling cranes shown in *Fig.* 2.

To make the river suitable for the navigation proposed much digging and dredging was needed, a sharp bend in the river was totally cut away, and to-day the wharf, nearly a mile in length, flanked by a channel 350 ft. wide, occupies the land which was three years ago a mud flat. Railway lines connect this wharf with a large siding, which is connected with the South Eastern and Chatham lines at Minster, and from the formation of this siding was obtained a great deal of the material for raising the surface of the port above its former waterlogged level. A hill which stood in the way was entirely removed, and the surplus earth was used for raising the whole surface to a uniform level, but the magnitude of the work will be appreciated from the fact that over 250 acres of mud flats have been raised from 5 to 8 ft. above high-water level.

Perhaps the most interesting feature of the port is the arrangement for the transhipment of goods to the "Channel Ferry." At the end of the wharf an electric "lifting" bridge has been constructed, and when the specially designed vessels are backed against the wharf, the bridge is lowered and adjusted so that trains may run from the land to the tracks on the vessel. These vessels are 363 ft. 6 in. long, 61 ft. 6 in. wide, and their draught varies from 9 to 10 ft. Their speed is 12 knots, they are protected by their own guns, and their capacity is 54 ordinary 10-ton waggons, though the average load carried on each journey has been about 900 tons. On several occasions during the war these vessels have unloaded, loaded, and taken up a supply of oil fuel in 21 minutes. They travel under their own power to Calais or Dunkirk, which are equipped with similar bridges at their rail heads, and the fact that English rolling stock will run on the French gauge has greatly fostered the scheme.

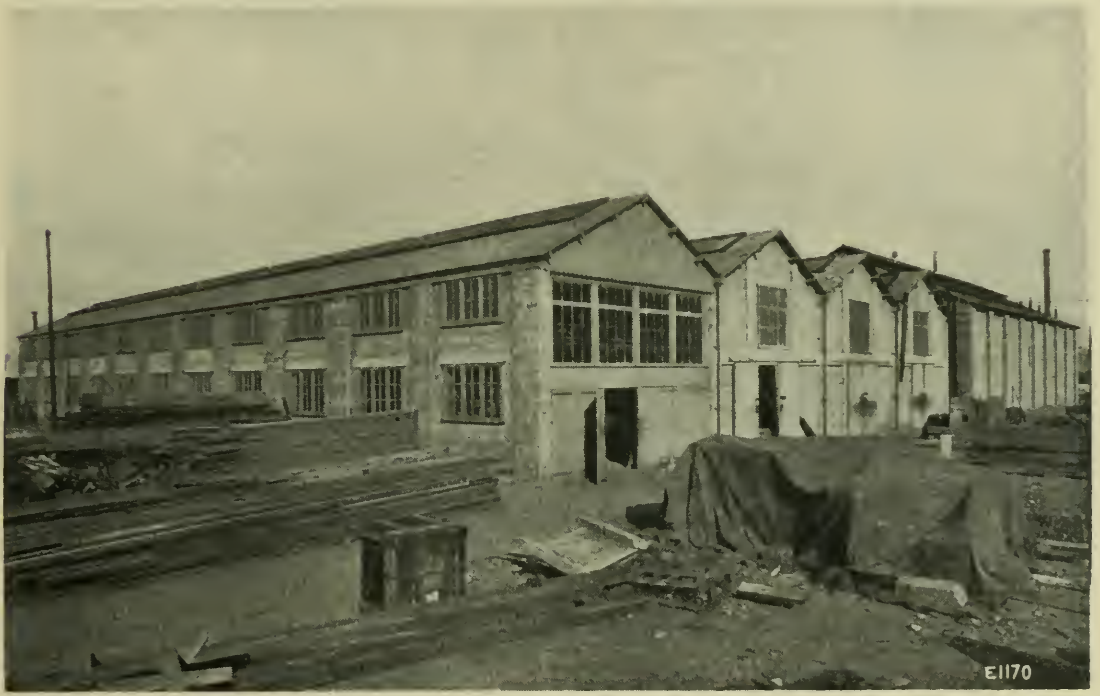


Fig. 7. Some Warehouses at Richborough Camp.

Besides these works necessary for transportation several camps capable of housing from 15,000 men have been built, and are shown in *Fig.* 1.

Huge engineering workshops, motor and aeroplane repair shops, and a large barge building depot form part of the scheme, and for these buildings concrete blocks made on the "Winget" machine have been almost universally used. Some of these buildings were described and illustrated in our number for March, 1918, and the same principle has been employed in the larger structures.

The whole of the buildings are erected as multiples of a "Unit" sized slab, plus a strengthening pier at intervals and at corners of the building. Where special strength was required, or on "risky" foundations, the corner and pier blocks were cast hollow and were threaded over steel reinforcing rods. Concrete was then poured into the voids, so that a type of reinforced concrete construction was obtained without the use of timber shuttering (see *Figs*. 6 and 7).

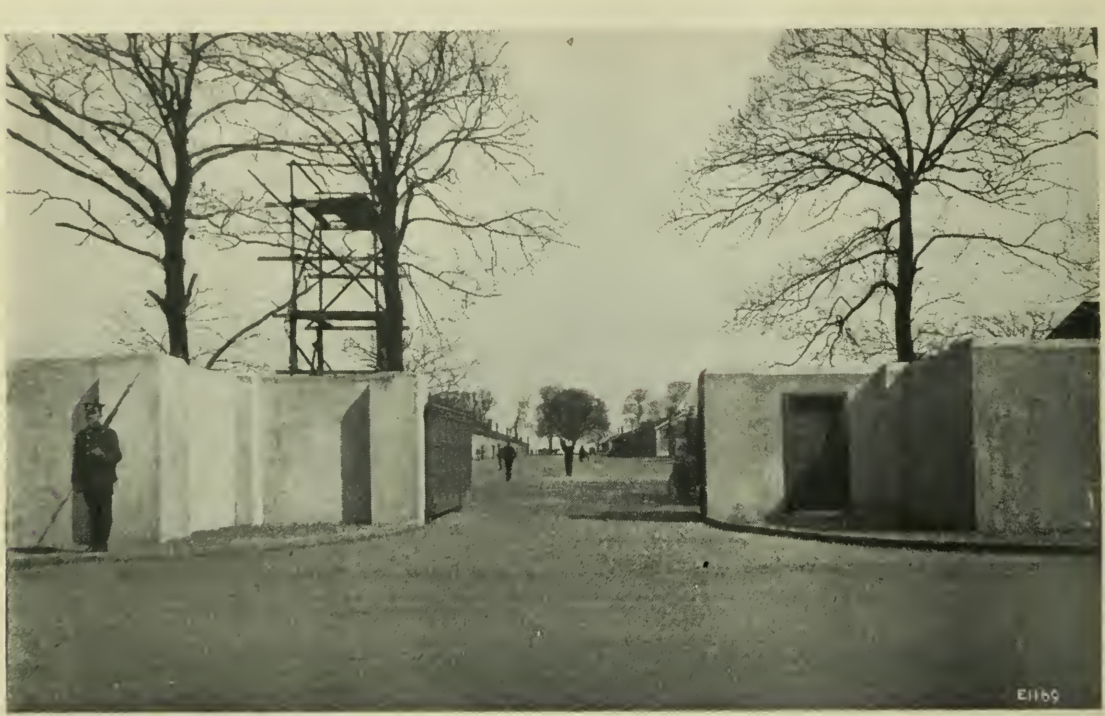
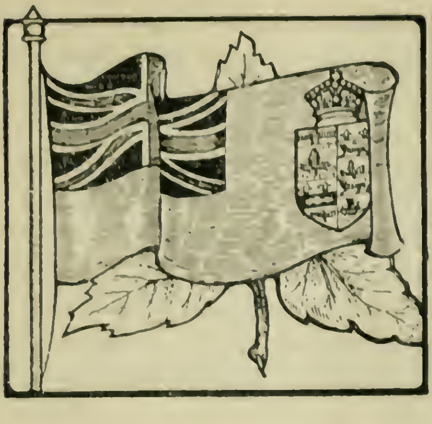


Fig. 8. A Concrete Boundary Wall.

Another feature of the scheme is the "Pill Box" yard, where reinforced concrete blocks have been made in great numbers; which blocks, when fitted together, form movable "pill boxes," which were specially designed for use in the front line trenches, and can be erected and in use within 60 minutes of the commencement of the construction.

Not far distant is the salvage dump, where all kinds of debris from the Front is being repaired, or prepared for re-use in another form. Millions of shell cases, old meat and food tins, broken boxes and ropes are here sorted by women and discharged soldiers, and nearly 200,000 tons of artillery salvage and other goods approximating to a value of £3,000,000 have already been dealt with.

The fuel for the supply of power and heating has been obtained from the Kentish pits a few miles distant, and it is possible that the port may play a great part in the development of the latent value of this coalfield also. Although its position eliminates its chance of becoming a deep-water shipping centre, it is to be hoped that its value as a commercial undertaking will be realised in the coming period of reconstruction. It is understood that towards the end of January an arrangement was come to with the South Eastern and Chatham Railway Co. to work the port, on behalf of the War Department, with civilian labour.



PROPORTIONING THE MATERIALS OF MORTARS AND CONCRETES BY SURFACE AREAS OF AGGREGATES.

By CAPT. LLEWELLYN N. EDWARDS,
Supervising Engineer of Bridges, City of Toronto, Ont.

The following is the first part of an important paper read at the Annual Meeting of the American Society for Testing Materials, dealing with some tests made by the author regarding the poportioning of the materials of mortars and concretes by surface areas of aggregates. The results of the tests made show that the strength of mortars depends upon the consistency of the mix and upon the quantity of cement in relation to surface areas of aggregates.—ED.

UNDERLYING the combination of inert aggregates with cement to form mortars and concretes the fundamental principle is that the proportioning of the cement in relation to the aggregates shall be such as to develop the full strength of the inert materials or shall secure conditions of strength, hardness, impermeability, or other desired physical properties. While the character of the aggregates and the amount of water used influence results to a marked degree, the proper proportioning of the cement is a matter of the utmost consequence, since this is the only active, strength-producing material entering into the mixture.

The " surface-area " method of proportioning assumes as its basic principle that strength, hardness, etc., are primarily dependent upon the relation of the volume of cementing material on the surface areas of the aggregates.

This paper has for its object the following :

1. To develop information relating to the average surface areas of sand and stone aggregates.

2. To describe the methods and materials used, the results obtained and the phenomena observed in a series of experimental tests undertaken to develop the practical application and efficacy of this method.

From a careful consideration of the results obtained and of the phenomena observed, the following conclusions appear to be warranted :

CONCLUSIONS.

1. The claim that the surface-area method of proportioning the cement content of mortars and of concretes is essentially scientific and rational is proven by the uniformity of results obtained in comparative strength tests of mortars and concretes and by the phenomena observed in these tests.

2. With a given uniform proportion of cement in relation to the surface areas involved, this method provides a definite and practical means of comparing the relative strength-producing qualities of aggregates of varying physical, chemical, and mechanical properties.

3. This method provides a means for a more thorough investigation of the functions of sand and stone aggregates and for a more complete development of the true values of all the component materials of mortars and concretes.

4. Excess water in an over-saturated mortar or concrete mix exerts a decidedly weakening effect upon the cement matrix by producing a change in the physical

structure of the matrix which tends to destroy the cohesion existing between the particles of cement and the adhesion existing between the cement and the aggregate.

5. In a normal consistency mortar the relation of the area of the particles of the sand aggregate to the cement content of the mix determines the strength of the mortar, provided the strength of the sand material is greater than that of the cement matrix. A similar condition applies to concrete mixes not oversaturated.

6. The strengths of mortars containing a given cement and sand, but varying for the different mixes in the proportions of these ingredients, are directly proportional to the relation existing between the cement content and the surface area of the aggregate. It follows, therefore, that, the strength of a mortar of given mix being known, the mix of a mortar having a desired strength can be predetermined for the same materials.

7. The quantity of water required to produce " normal," uniform consistency mortars from a given cement combined in varying proportions with sands having the same origin but varying in their granulometric composition is a function of the water required to reduce the cement to a " normal " paste and the surface area of the sand particles to be wetted.

8. The increase of volume due to the mingling of varying quantities of cement particles with a uniform quantity of a given sand bears no apparent relation to and is evidently not dependent upon the void in the sand.

9. The tests indicate a probable definite relation between the ultimate compressive strength of the mortar content and the ultimate compressive strength of the concrete when the test specimens of the former are produced from mortar of the same mix and consistency as that used in the concrete.

HISTORICAL.

The use of mortars dates from a time so remote that its beginning cannot be ascertained. However, its modern use in the form of an intimate mixture of lime or cement, sand and water doubtless dates back to the " constructive " Roman period. Both Romans and Normans well understood its use ; both had a thorough knowledge of mortar.

Doubtless the method of proportioning the cementing material and aggregates by volume originated among these early artisans. However, the earliest authentic record of its use is credited to General Pasley (1827). This method as commonly specified and used is not only illogical and unscientific, but also unfair to the development of the true value of the materials entering into the composition of both mortar and concrete.

Cement is the binder holding together the aggregates. The fundamental theory of the combination is that the two materials, the one active, the other inert, act as a single unit.

With regard to the item of strength, the ideal mortar contains a proportion of cement sufficient to develop the full strength of the particles of sand aggregate ; while the ideal concrete contains a mortar component, in itself ideal, which will develop the full strength of the particles of stone aggregate. The actual proportioning and combining of the cement and aggregates fall somewhat short of reaching this theoretical perfection ; practical considerations render it impossible to distribute the cement perfectly, and thus to secure that absolute adhesion between the particles of aggregate which is necessary to the perfect transmission of the stresses from one particle of aggregate to another. Perfection in this regard is, therefore, unattainable, at least in so far as commonly used field methods and operations are concerned.

Those having experience in practical tests of mortar and concrete know that, with given volumetric proportions of materials, comparatively slight variations in the granulometric composition of the sand aggregate produce marked differences in the strength, toughness, and other physical properties of the product.

There should be no place in engineering for guesswork and empiricism whenever scientific determination is possible. With this idea in mind and with a due allowance for the practical considerations mentioned above, it remained to set about about the task of finding a structural reason for the wide variations of strength obtained in mortar tests. In November, 1917, a most natural solution presented itself—namely:

1. The strength of mortar is primarily dependent upon the character of the bond existing between the individual particles of the sand aggregate. Upon the total surface area of these particles depends the quantity of cementing material. Furthermore:

2. The amount of water required to produce a "normal," uniform consistency of mortar is a function of the cement and of the surface area of the particles of the sand aggregate to be wetted.

This idea of proportioning the cement in relation to the surface area of the aggregate was new to the writer and appealed to him as a reasonable, although rather radical, departure from the time-honoured practice of proportioning by volume measurement. However, he discovered in February, 1918, that it is in reality at least twenty-five years old. Prof. A. H. Heath describes it very clearly in his book, *A Manual of Lime and Cement*, 1893, as here quoted:

"Sufficient cement should be used to furnish a coating to the surface of each particle of the matrix, and the extent of surface of particles as compared with their bulk is much greater with fine sand than with coarse sand. For instance, a 3-in sphere has one-eighth the bulk of a 6-in. sphere, but its surface area is one-fourth that of the 6-in.

"To ensure the perfect coating of each particle, a larger proportion of cement must be taken with fine than with coarse sand. If the proportion of cement taken for fine sand be that sufficient only for coarse sand, the cement films enveloping the particles will probably be imperfect, and the concrete will be deficient in strength."

No attempt was made by Professor Heath to develop the surface-area method of proportioning, of which he was a pioneer or possibly the originator.

This paper presents the results of tests made by the City of Toronto Department of Works, under the direct supervision of the writer.

OBJECT AND SCOPE OF TESTS.

The tests were made with the object of developing the surface-area method of proportioning and securing information relative to (1) the surface area of aggregates of varying granulometric composition; (2) the quantity of water necessary to produce a "normal," uniform consistency of mortar for varying sands and cement content; and (3) the strength of mortar attained by varying the proportion of cement in the mix.

The range or scope of the tests was sub-divided as follows:

1. The determination of the average surface area of sand and stone particles of varying sizes based upon an actual count of the number of particles in given weights.

2. The determination, by trial, of the quantity of water necessary to produce, for any given sand and proportion of cement, a mortar of "normal," uniform consistency.

3. The determination of the reliability of the surface-area method of proportioning mortars in so far as strength alone is concerned.

4. The determination of the relative strengths resulting from variations in the cement content of mortars within practical limits.

5. The securing of miscellaneous general information pertaining to the foregoing phases of the tests.

The investigations herein described involve compression and tension tests upon 240 mortar cylinders, 2 in. in dimeter by 4 in. long; 45 concrete cylinders 6 in. in diameter by 12 in. long; and 324 standard briquettes.

SURFACE AREA OF AGGREGATES.

Possibly the fact that the relation of the surface areas to the volumes of particles of matter depends upon their size and shape needs no demonstration; however, the following example will serve to bring this fact more clearly to mind:

Assume three masses of material, each made up of the following particles:

1. Spheres 2 in. and $\frac{7}{8}$ in. in diameter.
2. Sphere 2 in., $1\frac{7}{16}$ in., and $\frac{9}{16}$ in. in diameter.
3. Spheres $1\frac{3}{4}$ in. and 1 in. in diameter, 1-in. cubes, and parallelepipeds $\frac{1}{4}$ by $\frac{1}{2}$ by $\frac{1}{2}$ in. and $\frac{1}{2}$ by 1 by 1 in.

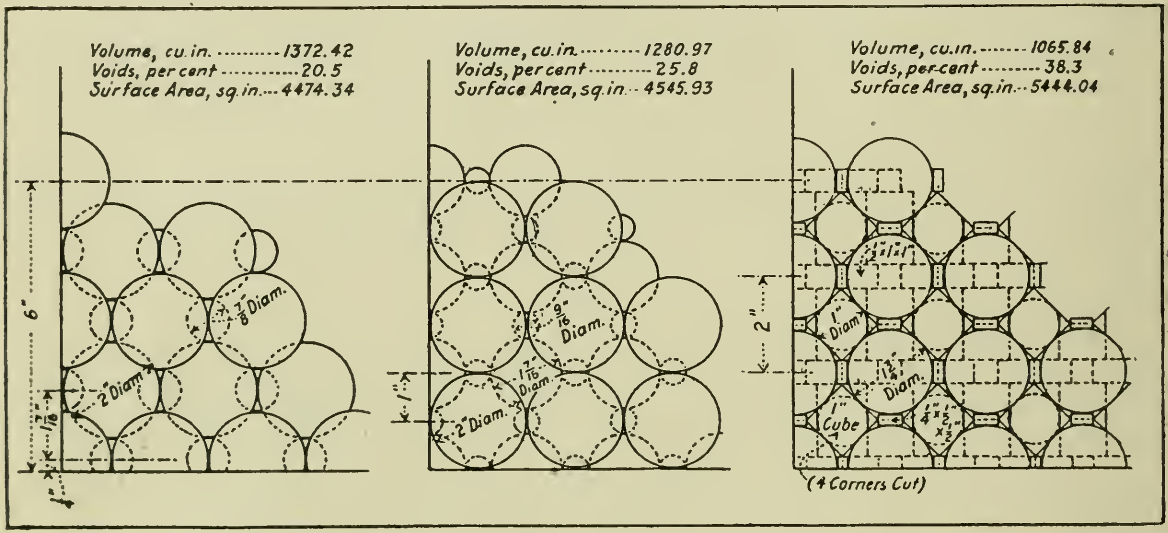

Volume, cu. in. 1372.42
Voids, per cent 20.5
Surface Area, sq. in. ... 4474.34
Volume, cu. in. 1280.97
Voids, per cent 25.8
Surface Area, sq. in. .. 4545.93
Volume, cu. in. 1065.84
Voids, per cent 38.3
Surface Area, sq. in. .. 5444.04
6"
2" Diam.
7/8" Diam.
1 7/16"
1"
9/16" Diam.
1 7/16" Diam.
2" Diam.
1"
2"
1" Diam.
1/2"x1"x1"
1 3/4" Diam.
1" Cube
1/4"x1/2"x1/2"
(4 Corners Cut)

Fig. 1. Relation of Surface Area to Shape of Particles.

Assume now 1 cu. ft. of each and that the particles are regularly arranged as shown in *Fig.* 1. Both the total surface area and the total volume in each cubic foot are readily determined. They are as shown in Table I.

TABLE I.—Relation of Surface Area to Volume of Particles.

Cubic Foot No.	Surface Area sq. in.	Volume Cu. in.	Relation of Area to Volume.	Relation to No. 1	
				Area per cent.	Volume per cent.
1.......	4474.3	1372.4	3.26 : 1	......	......
2,.....	4545.9	1281 0	3.55 : 1	1 6 greater	6.6 less
3.......	5444.0	1065 8	5 11 : 1	21.9 "	22.3 "

The shapes of particles of sand and of stone aggregates are infinite in number and for this reason no accurate determination of their surface areas is possible. However, it is reasonable to assume that these areas can be closely approximated. Doubtless these approximate areas do not vary greatly from the true areas in the finer particles of sands, since these particles, when examined under the microscope, appear more nearly spherical than do the larger particles of sands and of gravels.

Surface Area of Sand Aggregate.—As a preparation for the securing of information from which it would be possible to compute the approximate average surface area of sand particles of varying sizes (the exact area cannot be determined) samples of natural sands were secured from different localities. Each sand was thoroughly dried and divided by sieving into its component sizes.

For each sand the average number of particles per gram was determined, for every size of each sand, by an actual count. For the larger sizes 8 to 10 gr. or more, and for the medium sizes 3 to 5 g. were counted ; while for the smaller sizes 0·25 to 1 g. was counted. The results of these counts, together with the actual and the assumed averages for computation purposes, are given in Table II.

TABLE II.—NUMBER OF SAND PARTICLES PER GRAM.

Name of Sand.	Size of Sieve Passed and Retained on.							
	P4–R8	P8–R10	P10–R20	P20–R30	P30–R40	P40–R50	P50–R80	P80–R100
"Maple" Vaughan, Ont..........	14 75	56 28	403.56	1729	5686	16 891	45 086	72 511
"Pleasant Lake" Otisfield, Me...........	12.60	58.80	40.200	1673	5020	12 183	39 876	98 996
"Cataract" Caledon, Ont...........	10.93	56.17	366.70	1431	4303	15 010	39 510	102 116
"Erin" Erin, Ont..............	13.25	49.80	270 12	1449	4439	17 999	34 542	125 630
"Ontario Lake" Toronto, Ont...........	17.16	57.83	214 00	1409	4584	17 675	40 422	96 412
"Standard Ottawa" Ottawa, Ill.............	.....	.....	.....	1323	...	....	....	....
Average	13.74	55 78	331 28	1502	4806	15 991	40 057	99 133
Assumed Average for Tests	14	55	350	1500	4800	16 000	40 000	99 000

The number of particles per gram having been determined as above described, the specific gravity being 2·689 and the weight of water being assumed at 62·37 lb. per cu. ft., the volume per particle was computed as follows :

Weight of sand material = 62·37 × 2·689 = 167·713 lb. per cu. ft. = 0·09706 lb. per cu. in. = 43·0257 g. per cu. in.

Then

43·0257 × number of particles per gram = number of particles having a total volume of 1 cu. in.

TABLE III.—VOLUME AND SURFACE AREA OF SAND.

Sieve Passed and Retained on.	Number of Particles per Gram.	Average Volume per Particle, cu. in.	Average Diameter per Particle, in.	Surface Area per Particle, sq. in.	Surface Area per Gram, sq. in.
P 4 - R 8.............	14	0.001 66	0 146 95	0.067 8	0.9492
P 8 - R 10.............	55	0.000 422 6	0.093 1058	0.027 2335	1.4978
P 10 - R 20............	350	0.000 066 45	0.050 2534	0.007 9338	2.7778
P 20 - R 30............	1 500	0 000 015 49	0.030 928	0.003 0055	4 5083
P 30 - R 40	4 800	0.000 004 842	0.020 9893	0 001 3841	6.6437
P 40 - R 50............	16 000	0 000 001 452	0 014 0818	0.000 6201	9.9216
P 50 - R 80...........	40 000	0.000 000 5815	0 010 3568	0.000 336 913	13.4765
P 80 - R 100	99 000	0.000 000 2348	0 007 6538	0 000 188 325	18.6442
Standard Ottawa.......	1 323	0 000 017 57	0.032 2545	0.003 268 38	4.3241

Whence,

Average volume per particle

$$= \frac{1}{\text{Number of particles having volume of 1 cu. in.}}$$

The average volume per particle being determined, the shape of the particles was assumed as spherical and the surface area per particle and per gram of sand was determined accordingly. The results of these computations are given in Table III.

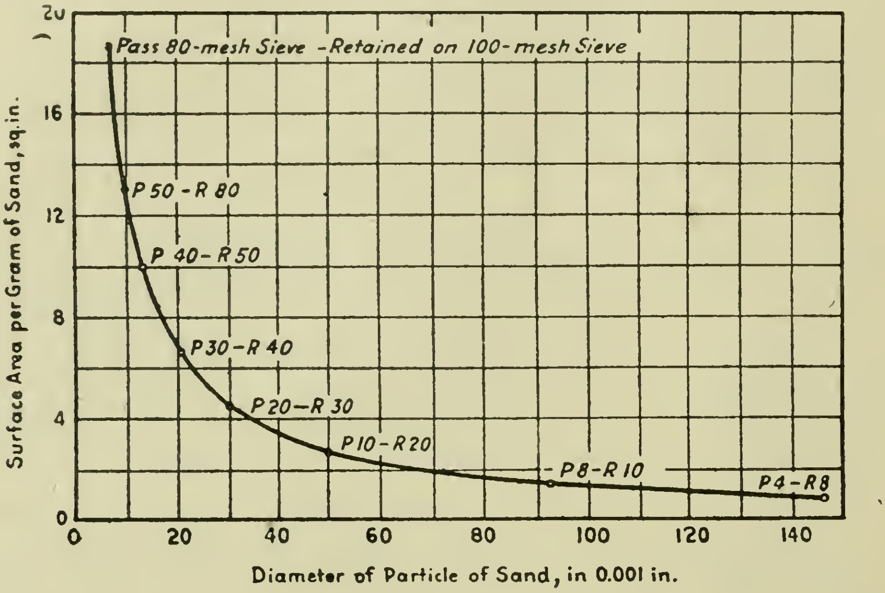


FIG. 2. SURFACE AREA OF SAND AGGREGATE.

These results, in part, are also shown graphically in *Fig.* 2. This curve of areas, although empirical, approximates very closely the curve represented by the equation $xy = 139$.

TABLE IV.—VOLUME AND SURFACE AREA OF STONE AGGREGATE.

BROKEN STONE.

Screen Passed and Retained on.	Number of Particles in 100 lb.	Average Volume per Particle, cu. in.	Surface Area per Particle, sq. in.	Surface Area per 100 lb., sq. ft.
P 2 - R 1½..............	670	1 553	8.7047	40.5
P 1½ - R 1	1 680	0 636	4.9261	57 47
P 1 - R ¾	5 680	0 1811	2 1139	83.38
P ¾ - R ½..............	14 900	0 0692	1 1943	123 58
P ½ - R ¼..............	43 820	0 0236	0.5339	162 47

SCREENED GRAVEL.

Screen Passed and Retained on.	Number of Particles in 100 lb.	Average Volume per Particle, cu. in.	Average Diameter per Particle, in.	Surface Area per Particle, sq. in.	Surface Area per 100 lb., sq. ft.
P 2 - R 1½......	430	2 4289	1.6678	8.7383	26 09
P 1½ - R 1......	1 090	0 9509	1 2201	4 6764	35 39
P 1 - R ¾......	3 830	0 2694	0 8013	2 0330	54 00
P ¾ - R ½......	10 030	0 1020	0.5797	1.0557	73 54
P ½ - R ¼......	37 330	0 0276	0 3753	0 4425	114 71

Surface Area of Stone Aggregate.—The shapes of particles of broken stone and of natural gravels are dependent mainly upon the character of the rock material of which they are composed, whether of igneous or of sedimentary origin. The former produce, in broken stone, particles more angular in shape and more rough of surface than the latter ; while in gravels the tendency of the former is to produce particles approximately more nearly spheres ; the particles of the latter are commonly flattened with rounded edges.

The method above described for sand aggregates was followed in the counting of particles, computation of average volumes, etc. In the determination of average surface areas the particles of broken stone were assumed to be made up of one-third cubical and two-thirds parallelepipedal shapes, the latter sub-divided to approximate more closely the areas of the elongated and slab-like shapes of particles. Gravel particles were assumed as spherical in shape. The results obtained for various sizes of particles are shown in Table IV. *Fig.* 3 shows graphically a portion of these results.

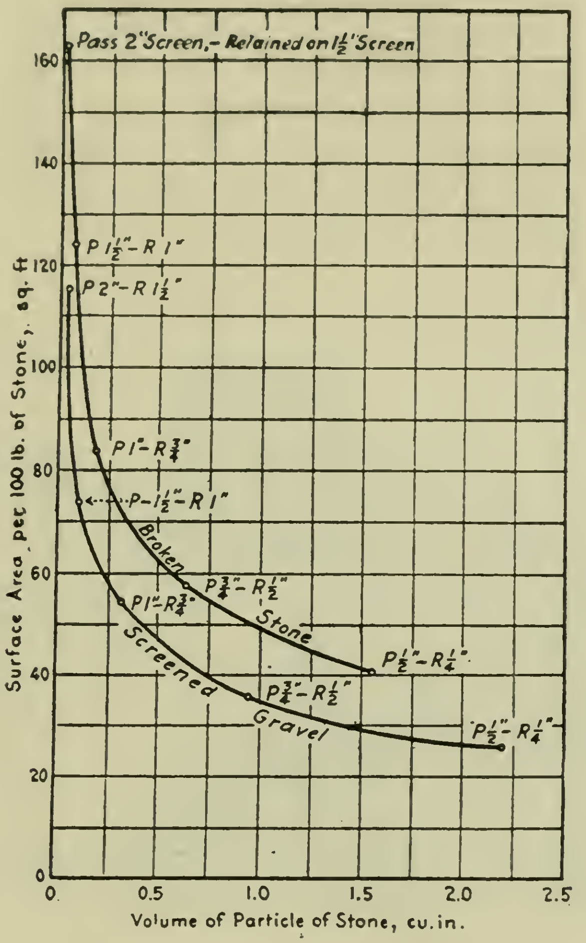


FIG. 3. SURFACE AREA OF STONE AGGREGATE.

(*To be continued.*)

RECONSTRUCTION IN DUBLIN.

New Premises constructed in Reinforced Concrete for Messrs. Eason & Son, Ltd.

In an earlier issue of our journal we referred to the rebuilding of some of the premises which had been destroyed in the rebellion of 1916. In the present article we are able to deal briefly with one of these buildings now in course of construction, and we are indebted for our particulars to Mr. J. A. C. Ruthven, architect for the building under review.—ED.

WHEN the rebellion of 1916 resulted in the conflagration which wiped out part of the principal centre of Dublin, the premises of Messrs. Eason & Son, Ltd., were completely destroyed.

The firm at once procured temporary premises to carry on their extensive business for that portion which consisted in the distribution of newspapers all over Ireland. The question of new and improved buildings was then considered, and plans were prepared and adopted. Messrs. Eason & Son, Ltd., are well known as the successors in Ireland of Messrs. W. H. Smith & Son, who opened their Irish branch in Dublin in 1850.

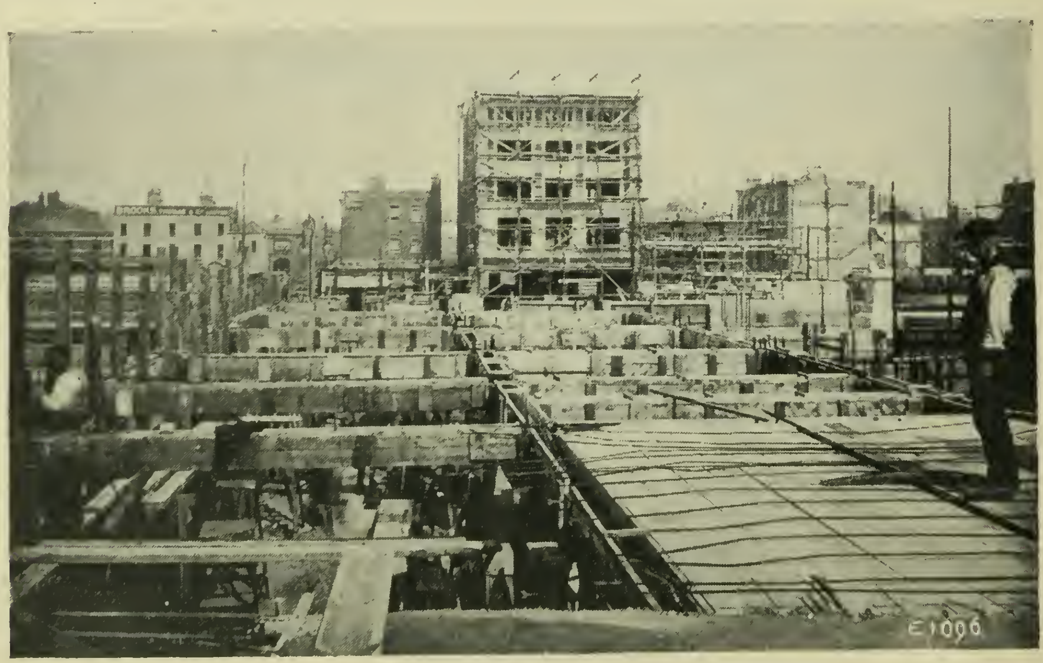


Fig. 1. First Floor Level facing Lower Sackville Street.
NEW PREMISES FOR MESSRS. EASON & SON, LTD.

Owing to prevailing war conditions many difficulties presented themselves in connection with the question of creating new buildings, and it was the cause of their destruction which led to the granting of permission to rebuild. The Government allowed a certain amount of material to be released for the purpose, but the shortage of steel and timber was a serious drawback, not only rendering

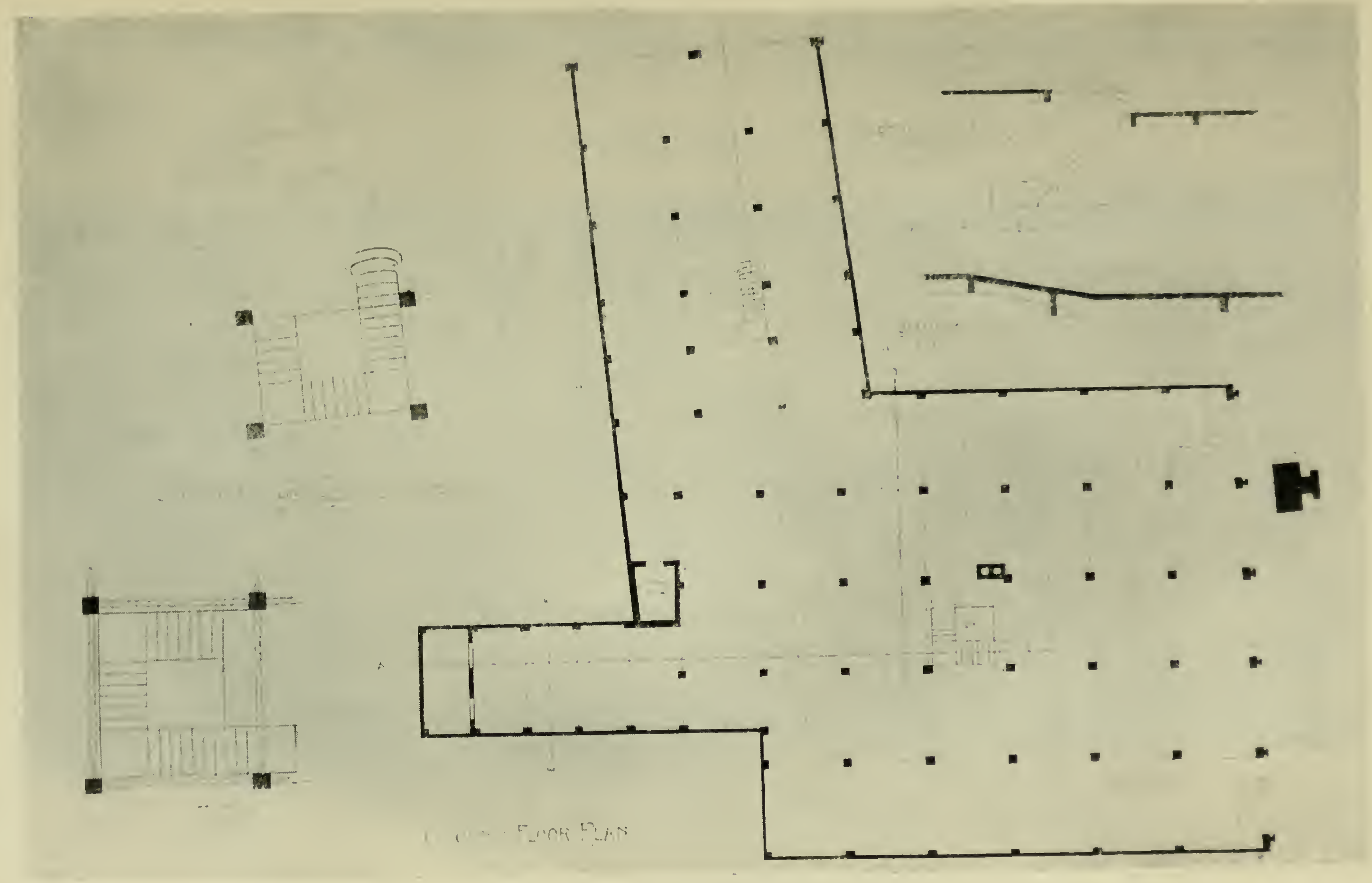


Fig. 2. General View of Site.
New Premises for Messrs. Eason & Son, Ltd.

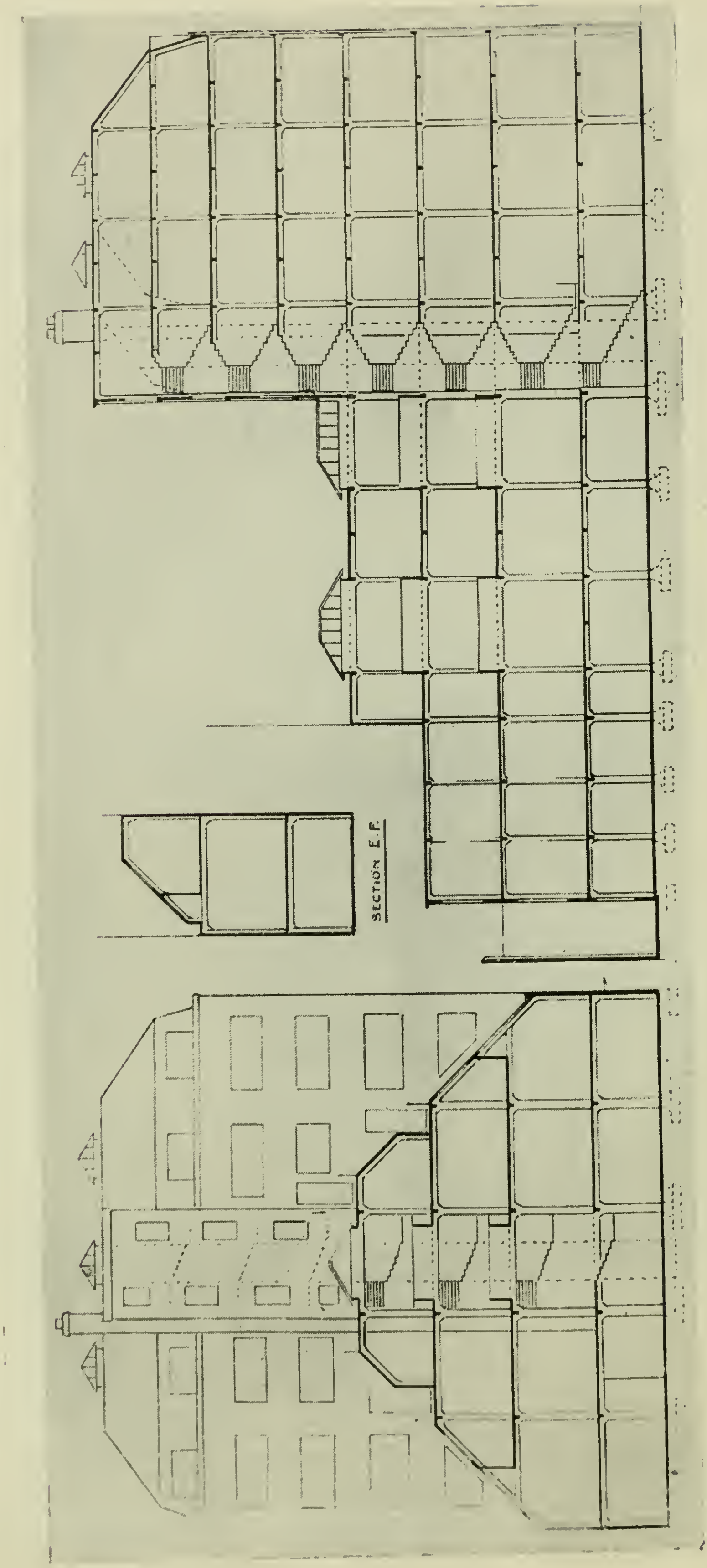


Fig. 3. Section C.D. Section A.B.

New Premises for Messrs. Eason & Son, Ltd.

it difficult to procure materials, but greatly increasing the cost of rebuilding. These considerations led to the adoption of reinforced concrete for the carrying out of the design. This form of construction was used for the entire building including the roofs, but excluding the fronts, these latter to be of Irish stone as

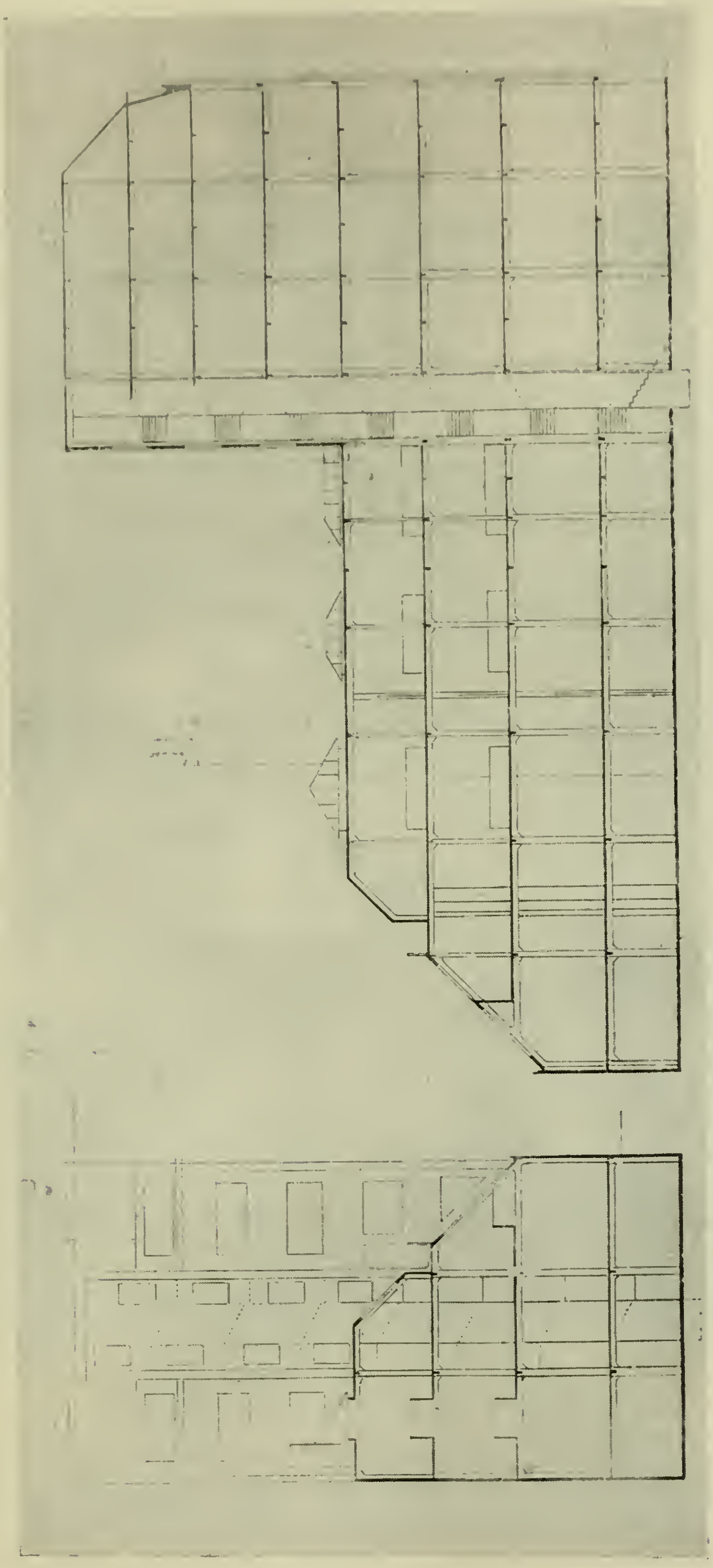


Fig. 4. Section G.H. Section I.J.

New Premises for Messrs. Eason & Son, Ltd.

far as possible. The system of reinforcement adopted by the architect was the Mouchel-Hennibique system and work was commenced in September 1917.

The difficulty in obtaining materials, especially timber for shuttering and latterly cement, and the shortage of labour has greatly delayed the work, but a considerable amount of progress has been made.

The site, as will be seen from *Fig.* 2, is somewhat irregular in plan, covering an area of 11,000 sq. ft., the frontage to Sackville Street (including No. 41, recently acquired) being 43 ft. 6 ins., and that to Middle Abbey Street, 79 ft. 6 ins. The main buildings behind these frontages consist of basement and seven storeys, and are 42 ft. and 60 ft. deep from front to back respectively. The connecting portion between these main buildings consists of basement and three floors, on same level as the others, so that these lower floors each form an unbroken expanse equal to the whole area, the total floor area being equal to 1½ acres.

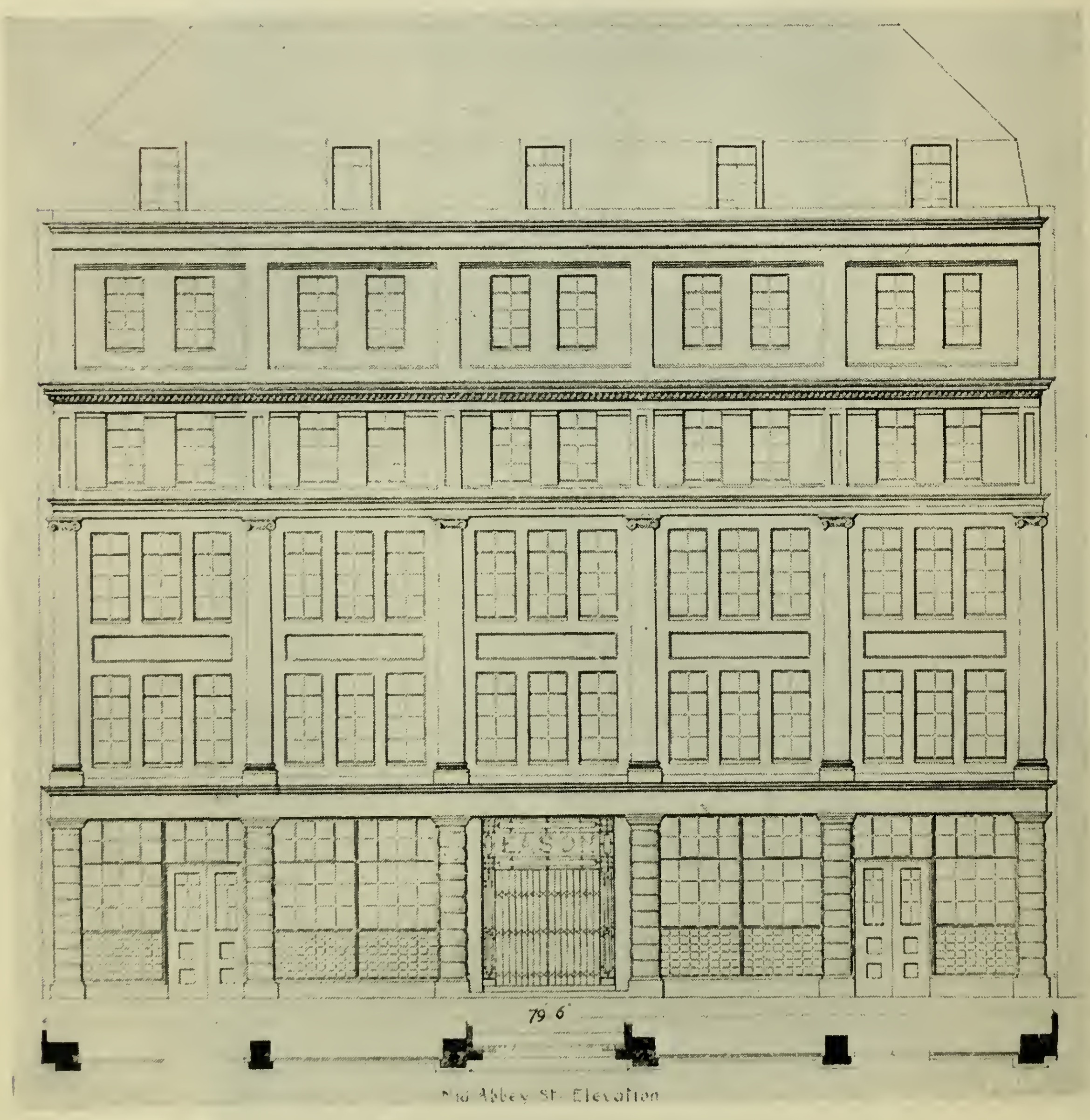


Fig. 5. Middle Abbey Street Elevation
New Premises for Messrs. Eason & Son, Ltd.

The roofs of the connecting buildings, as will be seen in *Figs.* 3 and 4, are sloped at an angle of 45 degrees in order to conserve neighbours' rights as to ancient lights, and not only does the flat roof of this portion provide an excellent emergency exit from either high building in case of fire, but advantage has been taken at a lower level of a useless angle of the floor to indent the roof and so form an additional way of escape.

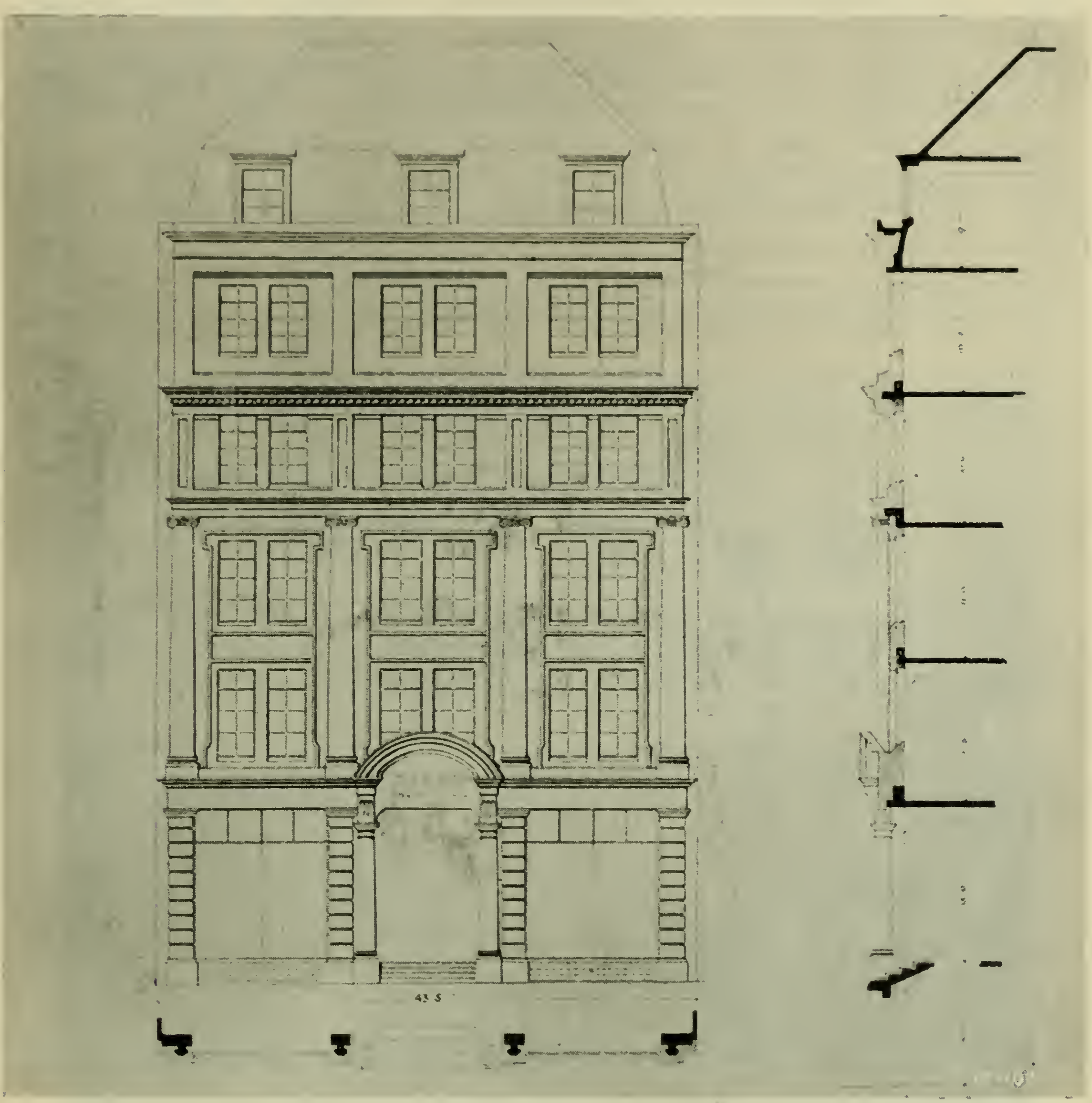


Fig. 6. Sackville Street Elevation.
New Premises for Messrs. Eason & Son, Ltd.

In each of the main buildings, a reinforced concrete staircase with an electric lift in centre of well hole, provides access to every floor ; and in addition, the Abbey Street building is provided with an electric goods lift. The order for these lifts has been placed with Messrs. Gimson & Co., Leicester. The Middle Abbey Street front (*Fig.* 5) is entirely faced with Irish granite from the Ballyknocken Quarries. The Lower Sackville Street front (*Fig.* 6) will consist of polished red Aberdeen granite to the level of facia, the remainder being Irish limestone from the Aughamadock Quarries, Queen's Co.

It is worth noting that an improved method of bonding these stone fronts into the reinforced concrete columns has been designed which has been found to be very effective. The reinforced columns are made with an anchor-shaped member in front, each alternate course of stone engages the perpendicular groove and thus the entire front is securely tied to the concrete without the aid of any exposed hoop iron or similar fastenings. This method would, of course, be equally effective in tying in brickwork to reinforced concrete buildings.

The buildings will be heated throughout on the low pressure hot water system, two Ideal boilers of large power being installed for the purpose. The entire premises will be lighted by electricity. Great attention has been paid to the sanitary requirements, the entire space in the small annex at the rear being given up to them, they occupy four floors, while at the top of the main building rest and recreation rooms will be provided for the female staff. The drainage is cast iron throughout, well provided with manholes, inspection and cleaning doors.

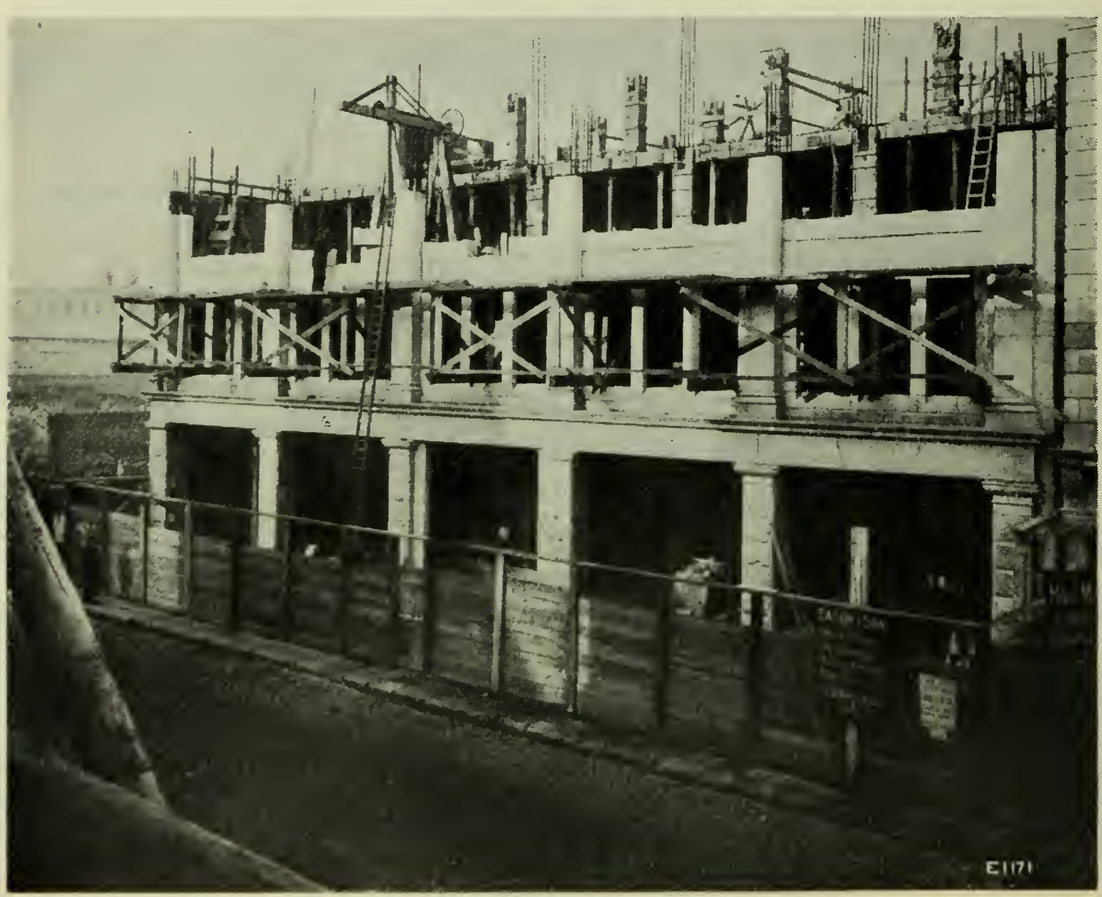


Fig. 8. View of Abbey Street Front.

The architect for the building is Mr. John A. C. Ruthven, Dublin. Messrs. J. & P. Good, Ltd., of Dublin, are the building contractors. Messrs. Bairds, Ltd., also of Dublin, are contractors for the heating and sanitary arrangements. Mr. Harry Hodges is clerk of works, and Messrs. L. G. Mouchel & Partners, Ltd., the proprietors of the Mouchel-Hennebique system are represented by Mr. R. N. Eaton, M.S.E., A.M.I.E.E., their engineer for Ireland.

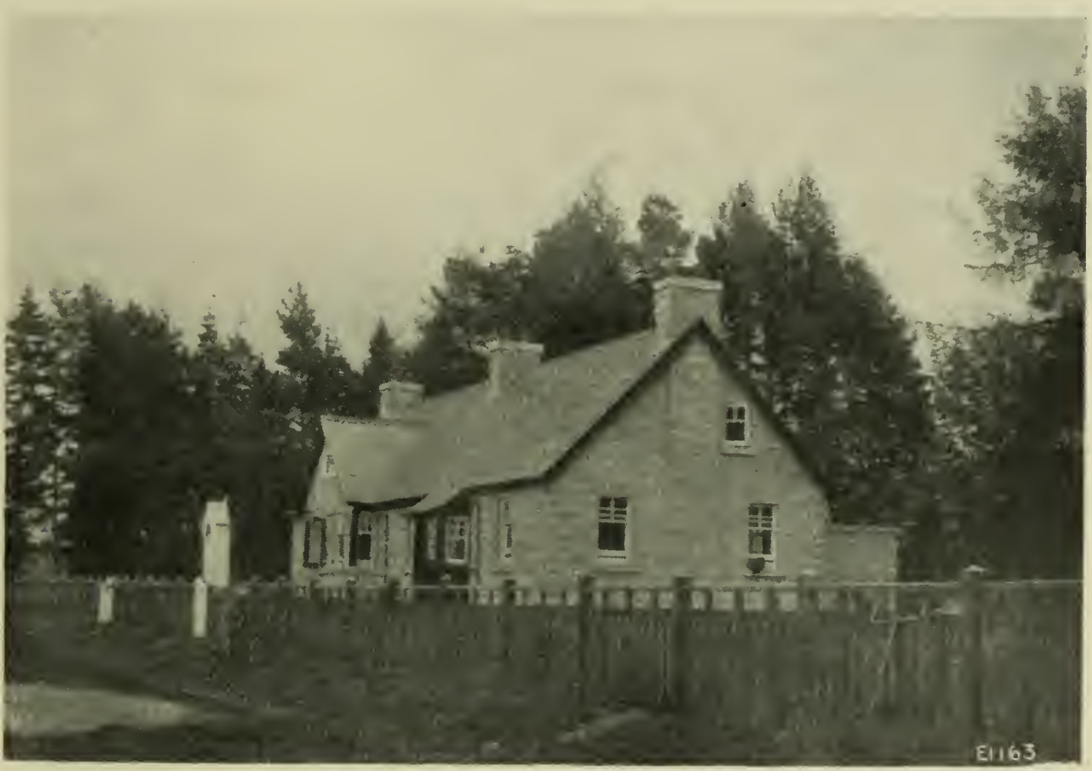
CONCRETE COTTAGES IN THE SCOTTISH HIGHLANDS.

AN EXAMPLE OF THE EFFICIENCY OF THE MOIST MOULDED SLAB CAVITY WALL IN AN ADVERSE CLIMATE

By EUSTACE W. PORTER, Assoc.M.Inst.C.E., etc.
Resident Engineer, Caledonian Canal, Inverness.

The following description of some concrete cottages erected on the Caledonian Canal contains many points of interest, especially at the present time, when the housing question is occupying much thought and attention.—ED.

The pair of cottages described and illustrated are typical of others designed and built by the writer for the accommodation of the lock-keeper staff on the Caledonian Canal (which is a Government undertaking) by departmental labour.



Concrete Cottages on Caledonian Canal.

The climate experienced in the great glen extending from Inverness to Fort William, which the canal serves, varies from an equable one at Inverness to the extreme at the west end, where the rainfall exceeds 78 in. per annum. It was, therefore, desirable to adopt a plan and type of construction which would make for comfortable housing under such conditions. Good building stone is not readily obtainable in the district, nor are suitable bricks, quite apart from the question of cost, which for such materials would be higher. Good gravel and pit sand is available at low cost, but against that advantage Portland cement is always expensive owing to freight so far north ; notwithstanding this, however, the cost of the concrete slabs employed was far less than for brick or stone.

Many who have not had the opportunity of using slabs made on the moist rapid-moulding system, such as the "Winget" or other similar machine will turn out, express doubt as to the strength and weather-resisting qualities of concrete prepared in such a way. The writer has found that briquettes made from the same mix as the blocks, which are moulded only just moist enough to bind and carry off the machine, employing the proportions and treating as described later, are capable of withstanding a tensile stress of 360 lb. per sq. in. at thirty-six days old.

The blocks were made two at a time in a hand-actuated moulding machine equipped with sufficient carrying-off plates to keep two men at the press and two men preparing the concrete, going all day. Special attention was given to the very necessary watering of the blocks while hardening, and none were used before they were twenty-eight days old at least.

The principal walls are built with a total thickness of 12 in., formed of 4 in. block outside, 2 in. cavity, and a 6 in. block inside. The blocks are tied together with $1\frac{1}{2}$ in. and $\frac{1}{8}$ in. iron wall ties immersed in neat cement grout. The outer blocks have their exposed faces finished with a moulded chisel face which (after the blocks are partly seasoned) are carefully brushed over in the direction of the chiselling (45°) with freshly made thin cement grout.

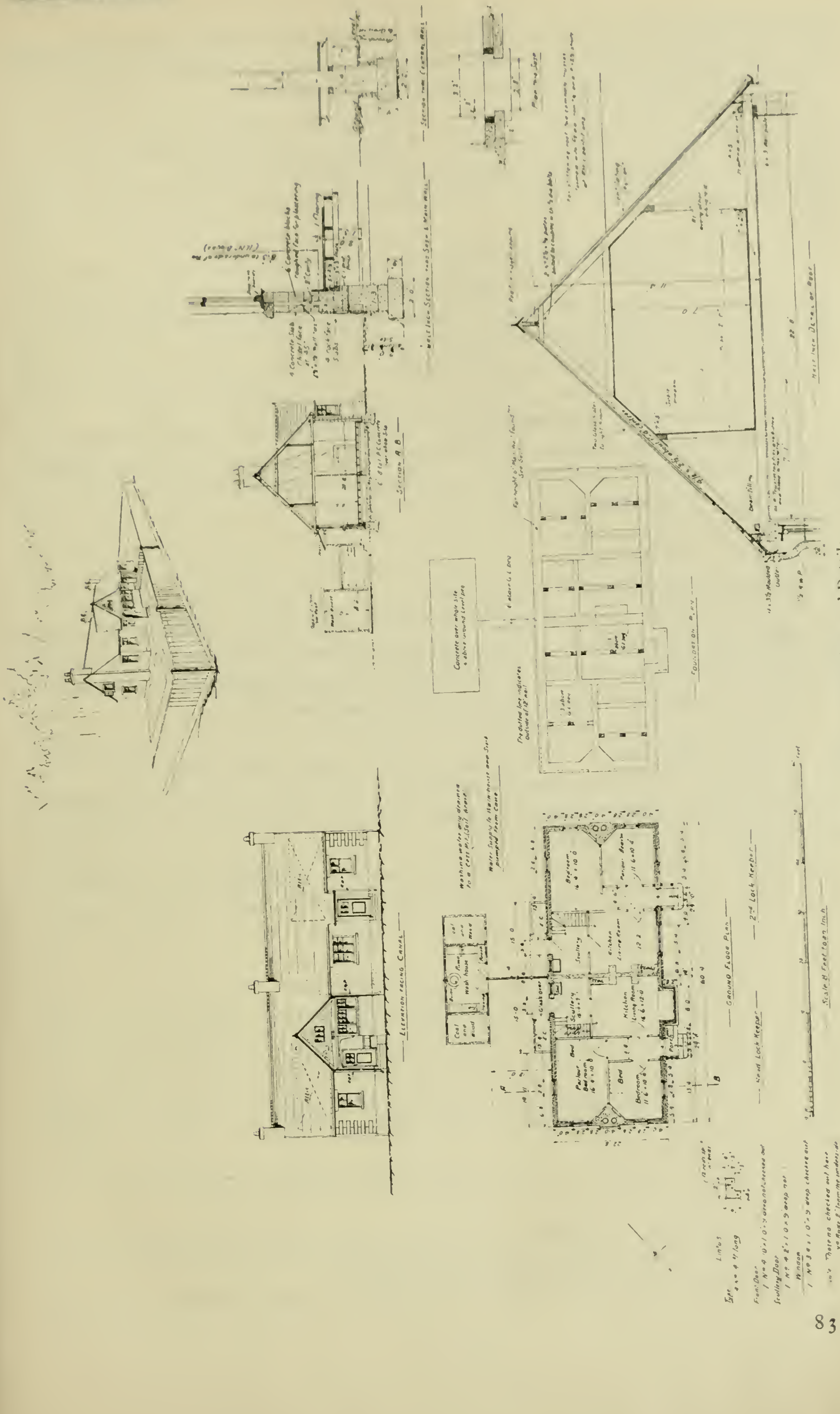
Treated thus before building it does not spoil the general effect of the face, and any porosity which might exist is entirely filled affording a weather-proof surface. The internal 6 in. blocks are finished with a plain face towards the cavity and a scratched surface inside to receive plaster.

Herein lies one of the merits of the so-called dry moulded block, or slab, for it is a great advantage to have the inner 6 in. thickness made porous, as such can be, to adapt the material for extremes of temperature without and within, and so prevent "sweating." The cavity system of construction in conjunction with this porosity admits of satisfactory plastering direct on the walls without lathing. The hollow block is excellent in some ways, but unless one laths there is the risk of dampness being conducted through the solid ends of such blocks.

The writer has seen patches plainly exhibiting this effect on the interior of finished walls, where such have been plastered without lathing. The length and height of the ordinary 4 in. and 6 in. blocks employed is 2 ft. $7\frac{5}{8}$ in. by $8\frac{5}{8}$ in., and it is found that these are of a convenient weight for a mason to handle economically.

The quoin blocks, or stones, are proportioned accordingly to break joint, as shown in the elevation (see Frontispiece). A $\frac{3}{8}$ in. Portland cement mortar joint was worked to.

The plinth courses (three in number) are of rock-faced blocks, and some trouble was taken to get a really natural form of face, by taking a mould of an



Plans, Elevations and Details,
CONCRETE COTTAGES IN THE SCOTTISH HIGHLANDS

actual specially hewn stone block of the same size, thus avoiding the very sham pitted appearance, which most of the marketed moulds produce, to say nothing of the bad weathering qualities of too bold a rock face.

The method of stopping the cavity wall at the sashes, and the reinforced lintels is indicated by the illustrations. The party gable wall is built in 10 in. block work, and the gable skew blocks, in both outer and party walls are of 12 in. and 10 in. thickness respectively solid and moulded to the pitch of roof which is 45°.

The " mix " for all the blockwork was apportioned from time to time according to the gravel and sand delivered, the average proportions being 12 parts of $\frac{3}{4}$ in. screened gravel, 6 parts $\frac{1}{4}$ in. screened sand, 3 parts Portland cement conforming to the British Standard Specification.

The " mix " for covering the site of the cottages, with 4 in. to 6 in. of cement concrete, was 26 parts gravel, $10\frac{1}{4}$ parts sand, 4 parts Portland cement.

The chimney stacks were built in 4 in. chisel-faced blocks, with a wet moulded concrete capping, with sufficient space between the fireclay vent lining to admit of a liberal thickness of lime mortar to obviate cracking, which sometimes occurs through heat of chimney if set entirely in cement.

All sills were cast in situ.

The floor level throughout is 2 ft. above the general ground level, and ventilated by vermin proof cast-iron gratings.

All the external walls are plastered direct on the 6 in. blocks, the deep scratching forming a " key " The internal partitions are of wood, lathed and plastered in the usual way, the roof principals being designed to span between the outer wall without relying on intermediate support.

As will be seen from the plan illustration the accommodation on the ground floor is three rooms and a scullery, and a good attic-room above with access from the scullery. The arrangement provides a comfortable kitchen-living room, free from draughts and of maximum size, and the scullery is sufficiently large to accommodate a portable bath.

In the case of two other cottages, built similar to the gabled one of these, a second attic room was provided, owing to the occupiers having larger families ; the small extra cost being merely that of the necessary flooring, partitions, and ceiling, with ventilating lights.

The carpentering work calls for no special comment. The timber used was Scots fir for the heavier scantlings, and imported red and whitewood for sashes and flooring, all joinery being of substantial character for ultimate economy. Chair rails and flush picture battens were provided. The walls of the rooms are finished with Hall's distemper tints according to situation. Deep sash-boards facilitate ventilation at the meeting rails without draught. The bay window has a fixed bench seat.

The space in the gable over the porch forms pleasing accommodation as a sewing room.

Every convenience is afforded in the way of cupboards, shelves, and hat and coat rails in the entrance lobby and under staircase.

The roofs are covered with Ballachulish slates in some instances, and with good effect with green Penrhyn slates in another, overlying felt and ¾ in. boarding. The ridging and finial is in ornamental red earthenware, as are the vent cans.

The fencing is an attempt to conform with the design of the cottages, posts of oak, rails, and pales of Scots fir.

Joint wash-house accommodation, with water supply, tubs, and ironing benches with separate wood and coal houses, is provided in a 4 in. concrete block building at the back, with separate entrances. E.C.'s adjoin the scullery doors and are built in 4 in. concrete blocks.

The roof of the wash-houses is of reinforced concrete laid in situ, that of the E.C.'s is formed of reinforced slabs precast.

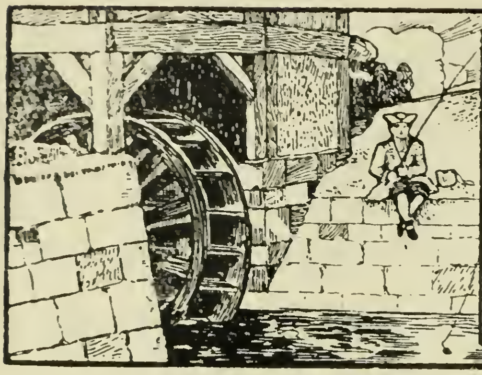
The wash-house boiler is that known as "The Devon," twelve-gallon portable. Water supply to that, the washing trough, and scullery, is from a tank on the roof of wash-house, supplied by a pump in that building, drawing from the Canal.

The entire cost of the pair of cottages illustrated amounted to £420, or about 5d. per cu. ft., ready for occupation in every respect, but, it must be observed that this was in 1914, when the cost of labour and material was not so high. The site is on the property of the Canal Commissioners, and the work being carried out departmentally was effected at prime cost, and involved no architect's fees.

Where a single cottage of the same type has been built, that with a gabled roof over the living-room window has been adopted.

As it is nearly four years since the cottages were completed sufficient time has elapsed to safely say that the dry moulded block cavity wall can be relied upon to give satisfaction in a damp climate, and with an exposure subject to boisterous winds.

In conclusion, the writer desires to express his indebtedness to the Canal Commissioner's chief engineer, Mr. L. John Groves, M.Inst.C.E., of Ardrishaig, for permission to publish an account of these cottages—works that form some of the many and ever increasing ones in concrete that fall to the lot of one to design and construct, and which it is hoped may prove of some interest to readers.



THE HOUSING PROBLEM.

Extract from the Report issued by Sir J. Tudor Walter's Committee, appointed by the Local Government Board to consider Questions of Building Construction in connection with the Provision of Dwellings for the Working Classes.

Continued from January Issue.—ED.

PART IX.—ECONOMY IN CONSTRUCTION (*continued*).

207. One question which generally arises in connection with the use of concrete is whether it is more economical to take the machines to the building site and there to manufacture the blocks, slabs, etc., or to set up a factory on a site near the source of the aggregate, and distribute the manufactured parts to the different building sites. In favour of manufacturing on the former, it is pointed out that the aggregate and the cement must in any case be taken there, and can be moved more cheaply and with less danger in the raw state than after manufacture. On the other hand, making on the building site may result in the use of insufficiently matured blocks, whereas in factories at convenient centres large stocks of standard units can be kept to mature. At such centres it is worth while to instal the most complete and economical machinery for crushing, grading, and mixing the materials and manufacturing the blocks. Experience both in supervision and in the actual work accumulates in such a factory ; the work may be carried on under cover and is not interrupted by bad weather ; a thorough knowledge of the class of material likely to contain impurities can be acquired ; tests can be frequently carried out. It would seem, therefore, that the disadvantage of conveying the finished product to the building site might often be outweighed by the advantages of more scientific and better organised production which is possible in a permanent factory. There will no doubt be districts in which a suitable aggregate exists on or near the building site and where no factory is available within a reasonable distance ; in these cases it will prove more economical to instal the necessary plant and make the blocks on the site. There are one or two portable machines for crushing, grading and mixing the concrete and for making blocks which can be readily set up in inexpensive sheds, and the use of these has proved in many cases very economical.

208. Reference has already been made to the grading of the materials in concrete ; it is important that this should be properly carried out, particularly if it is desired to secure a waterproof product or one of maximum strength. It must be realised that an aggregate of a porous material cannot be expected to give a waterproof concrete, nor can a weak aggregate result in strong concrete. Where a waterproof concrete is required, therefore, an aggregate must be selected the particles of which are themselves impervious ; and must then be graded so that all the voids are completely filled by smaller particles. Theoretically speaking, the perfect concrete would be that in which the grading of the sizes is gradual, so that each void is filled by the maximum-sized particles that can be introduced into it. When material is so graded, the quantity of cement required to cover completely the surface of all the particles and cause them to adhere is reduced to a minimum. Where a large quantity of concrete has to be used, care in the correct grading of the aggregate will be amply repaid, as it should result in a saving of cement. When concrete is made with good quality cement and an aggregate, the particles of which are themselves impervious, it should be waterproof, and generally if it is not so it may be assumed that the grading has not been good, that the mixture of the cement with the aggregate has been imperfect, or that the complete hydration of the cement has not taken place. Where concrete of good quality does not entirely resist water soon after it is made, its power of resistance will improve if it is moistened from time to time. Where materials which themselves are porous have to be used for the manufacture of concrete which is required to resist the weather, it will be necessary to have an outside coating of finer impervious concrete or cement rendering. Generally, therefore, it will be better to reserve porous materials for the inside linings of walls and interior partitions, where the permeability is not a disadvantage, and indeed may be an advantage in preventing condensation, and where the possibility of fixing by means of nails is a convenience.

209. There are many methods of using concrete for walling to which reference should be made. There is the *in situ* method, which consists of pouring or shovelling the wet concrete into a temporary mould. Each layer of concrete should be laid before the last is completely set ; this secures the maximum strength of the structure and makes complete use of the nature of the material in developing the strength and stability of the building. There are, however, practical objections to this system :— It requires centreing, shuttering or moulds which have to be kept in position for some time before they can safely be removed ; the concrete is liable to crack ; usually it is difficult to provide a porous inside surface, and trouble may, therefore, arise from condensation ; the external surface usually requires to be finished either with cement rendering or distempering. In this type of concrete walling the following objections, which hold good to a limited extent in connection with much concrete work, would have their maximum of force :—

1. It is difficult to obtain a hold for fixing.
2. Chases for pipes, wires, etc., cannot easily be made.
3. It is difficult to effect repairs.
4. Considerable trouble is experienced in carrying out alterations and additions.

To avoid the cost of complete shuttering or moulds, movable moulds have been introduced which are moved round or up the building, supported by the concrete already set, thus enabling the walls to be built up in stages.

210. Another system consists of casting in a horizontal position either the complete side or a section of the side of the building, and placing it in position after it has become set and hardened. In some cases the whole side of the building has been cast in this manner, and the frames for windows and doors either cast in or openings left the exact size to receive them. It is practicable to secure an impervious external surface by means of a first layer of rich concrete laid in the mould, while the internal surface may consist of a more porous mixture of the same materials or a lining of breeze or other similar porous and non-conducting concrete, screeded to form the inner surface. If such a method can be successfully adopted and a sufficiently impervious exterior be secured, with a porous interior face, it is probable that in this way adequate strength would be obtained for the building with a minimum amount of material. Only an experiment on a large scale could thoroughly test the capabilities of this method. One of its chief advocates admitted that the necessary machinery, cranes and organisation required to carry out the method effectively would only be justified in connection with a fairly large scheme, but was of opinion, as a result of experiments, that in such a case the economy obtainable would be very substantial ; the floors, roof, etc., would be cast in slabs in a manner similar to the walls, and the parts would be put together, the joints being dovetailed, reinforced where desirable, and run in with cement so that something approaching to the monolith construction would eventually result.

Modifications of these systems have also been adopted with satisfactory results ; in some cases, walls have been constructed of fairly large slabs which, when fixed, are strengthened and connected by piers or pilasters cast to cover the joint and support the slabs.

211. A form of construction has also been proposed, consisting of piers which are reinforced, and when put together result in a reinforced framework for the house ; different methods of filling in the panels can be used with such a framework. Narrow vertical sections, the height of one storey, may be employed, the joints being run in after the slabs are erected, or slabs of more usual type may be built up as a filling to the framework, and may be constructed in two thicknesses, one to give the impervious outer surface and the other the porous inner surface of the wall.

212. Further experience on an adequate scale is required to test these methods before it will be possible to determine their relative values from the point of view of economy. It is impossible to judge from small experimental examples of such new forms of construction, how they would work out as to cost, when repeated to an extent which would enable the workmen to get accustomed to the method.

213. The system of concrete walling which has been most widely adopted in connection with cottage construction is that of building either with blocks in a similar manner to solid stone walling, or with slabs on the lines of cavity brickwork. The majority of those who advocate the use of concrete for cottage construction recommend cavity walling formed of blocks or slabs, as being the method which, taking all the circumstances into account, is the most practicable and most likely to produce a satisfactory result.

By adopting the complete cavity, the danger of a damp house owing to want of skill or want of care in the making of the blocks is reduced to a minimum ; also with a complete cavity, types of concrete blocks or slabs may safely be used which are not completely impervious to moisture. Where complete impermeability is not required, the concrete can be mixed in a semi-dry condition, and the exterior surface may maintain the gravel or sand finish not discoloured by the cement. In this way a mixture similar to stone is produced which does not require any treatment, and, therefore, entails no maintenance expense in repeated coating with distemper or whitewash. Where blocks are made in a machine face downwards it may be possible, even if wet concrete is used, to secure a sand face.

214. A number of different shapes of block have been suggested to secure a bond without wall-ties ; it will be understood, however, that if such a bond is used the complete dryness of the interior wall must depend on the external slabs or blocks being themselves completely impervious to moisture ; if they are not so, damp is liable to be conveyed by the bond to the inner block. While, therefore, some of the suggested forms of bond have decided advantages from the stability point of view, we think that the blocks should be made under such skilled supervision and with materials which will secure complete impermeability in the outer blocks ; the inner blocks may then be made of a more porous material which would resist condensation. A block on the lines just described has been extensively used in Australia, more than a thousand houses having been built with it in the year immediately preceding the war.

215. Somewhat similar to the blocks just described is one which is strengthened with vertical ribs on the inner side, varying in depth to suit the height of wall, etc. The ribs are so spaced that they will take strapping, lathing and plastering to form the inner surface of the wall on the lines commonly adopted in Scotland for the treatment of the inner surface of brick or stone walls ; provided the ribs can be constructed to afford good hold for nails and at the same time not to transmit moisture, other forms of internal lining could be equally well used.

216. Another form of block has been suggested, in which the inner and the outer portions of the wall are made at the same time and are secured together by metal ties ; with the use of this block a section, including both parts of the hollow wall, is laid at one operation. It is possible with this arrangement to give a very secure tie and to increase the thickness of the slabs where ties occur, reducing them in the intermediate spaces ; but whether such blocks can be readily handled can only be tested by experience.

217. In reference to the interior portion of cavity concrete walls, breeze has the advantages of being light, porous, and a good non-conductor ; on the other hand, its strength is small and somewhat uncertain for the inner part of the wall which is liable to concentrated loads on the ends of lintels and under beams, etc. Experiments may reveal mixtures which would include the qualities of porosity, non-conductivity, capacity for holding nails, with a greater degree of strength and reliability than has hitherto been associated with breeze concrete. Experiments are being made with concrete, part of the aggregate of which is composed of specially-prepared burnt clay, sawdust or wood-powder, and in other cases of certain chemical by-products. Tests are being carried out as to the stability of different kinds of slabs. In the meantime, we consider that for the internal portion of cavity concrete walls, a slab having a margin of thickness over and above the minimum which appears to be necessary should be provided. We think that 4 in. slabs, if well made, should afford carrying power for ordinary cottage buildings, but where exceptional loads are thrown on to particular points of the wall, owing to the construction of a floor, some strengthening at such points is desirable. It should be recognised that lintels over any considerable width of opening must throw a special load upon the ends of the slabs forming the margin or jamb of the opening ; it may be that some reinforced concrete jambs may prove to be valuable in connection with slab walls and partitions ; but where such are not adopted, it is important that the lintels should have more bearing at each end than is frequently allowed ; indeed, a greater length of bearing would often be desirable, even with brick walls, and would frequently prevent many small cracks or settlements at the corners of openings.

218. Before leaving the question of concrete walls a word must be said about the different methods of waterproofing. A number of specifics have been brought to our notice ; some aim at filling up the pores of the concrete with lime, soapy or oily substances ; many of them have a certain amount of effectiveness, but the best concrete experts seem generally to have the least faith in the advantage of such expedients and to be most in favour of depending on the proper mixing of the concrete itself. The admixture of small quantities of lime seems in some cases to be beneficial, but the exact effect of the mixtures of lime with cement, and conversely of small quantities of cement with lime in lime mortar or concrete has not been thoroughly investigated, and researches are in progress. With the evidence before us, we are inclined, on the whole, to consider that the patent expedients may be found useful to correct failures, but that where concrete is required to be completely impervious to moisture, it should be made with sufficient care and with materials calculated to produce that effect.

219. In view of the possible scarcity of bricks, and the importance of curtailing unnecessary transit in the period immediately after the war, we recommend that, in districts which are situated at a distance from brickfields, and which possess suitable aggregates, concrete construction should be carefully considered for the erection of dwellings. We are convinced that if care is exercised and skilled supervision secured, good serviceable houses can be produced.

220. Apart from the brick and stone construction, the chief alternative proposal to concrete for the walls of permanent cottages consists of hollow brick or terra-cotta blocks. It is claimed that a given quantity of clay will go much further if made in the form of hollow blocks, that these blocks are lighter to handle and that, therefore, less labour is required for building the wall, and that the wall can be more quickly erected. A smaller quantity of mortar is required, and with some clays the mid-feathers connecting the two faces of the hollow block would be sufficiently impervious not to conduct damp across the cavity. Some makers recommend that the blocks should be left rough and rendered on the outside with cement to ensure their being weather-proof. It is further claimed that condensation trouble has not been experienced with hollow brick blocks and that houses built of such blocks can safely be occupied comparatively early after completion.

Various patterns of these hollow blocks have been suggested ; in one type the hollows run vertically, enabling corners or other places where piers are desirable for carrying extra weight to be strengthened by filling up the vertical cavities with concrete, in which can be inserted steel reinforcements if desirable ; other systems have cavities running horizontally, which gives a better bedding edge, and probably enables a firmer joint to be secured, but is not quite so strong as the alternative arrangement for carrying a concentrated load. It is doubtful whether houses built of these hollow blocks for the lower part of the building would be strong enough to resist occasional damage due to accident or mischief, except in the case of very strong clays and blocks with very thick external face ; but for the upper storeys of buildings where they are not liable to such rough usage they might prove both economical and serviceable. One maker suggested that an 11-in. hollow brick wall should be used for the ground storey and hollow brick blocks 6 in. thick for the upper storey. This would have the advantage of adding 10 in. to the length and breadth of the bedroom floor.

221. Hollow brick or terra-cotta lends itself to the formation of other parts of the building besides the actual walling. Hollow-brick members combined with steel reinforcement have already proved efficient for fireproof floors and this system could be extended so that it would be practicable to have lintels, heads, sills, mullions, jambs and other parts of the building constructed with such materials reinforced where necessary, and all made of standardised sizes to fit in with the wall blocks. It seems probable that the adoption of some such system would be required to secure the full economy of hollow-brick construction, and that, if the production on these lines were organised in certain districts, it might form a very useful additional method for constructing cottages. Whether the making of such blocks would reduce for the time being the total output of bricks available for cottage building is a consideration which might determine how far this method would afford a useful alternative for building immediately after the war, when, in all probability, brickworks will have to be run at their full capacity for some time to meet the demand for ordinary bricks. Apart from this consideration the method appears to offer a possible economical type of building, and one worthy of a thorough test.

222. Both hollow brick and concrete in various forms have been very extensively used during the war for the carrying out of various emergency works. Considerable experience has been gained as a consequence, and probably the number of men available who are accustomed to handling these materials will be considerably greater after the war than it was before, but, in spite of this fact, and of the possibility that in certain districts these alternative methods of construction may lead to substantial economy, we think it probable that the majority of houses erected in the period immediately following the war will be constructed of brick and stone in the manner to which contractors and workmen are generally accustomed.

223. For cottage work highly finished bricks pressed to one exact shape or selected to match exactly in colour and texture are not necessary. Good common bricks, well burnt and of a nature to resist the disintegrating effects of the weather, laid with an adequate joint, will meet the case and will be easy to produce in large quantities. But in view of the probability that the demand for bricks may exceed the supply it will be very necessary to select the most durable makes for exterior work, and to avoid those kinds of bricks which have proved unreliable. Evidence was given to us that some makes of bricks have a life of thirty or forty years only. Some clays contain impurities, such as chalk, lime, sulphate of lime, flints, etc., which are liable to lead to disintegration ; other clays when passing through the pug-mill are liable to maintain permanent laminations, and wet and frost attacking such bricks may disintegrate them. In addition to these defects there is the possibility of bricks being underburnt.

We consider that, as the whole production of bricks is likely to be required, special measures will have to be adopted to prevent defective bricks being supplied for external use, and to secure that the less durable or less thoroughly vitrified bricks are not employed for such purposes.

224. With a view to utilising every alternative kind of material and class of labour, stone walling for cottage building should be carefully considered in those districts where a suitable walling stone abounds. We are aware that of recent years, even in stone districts, the brick cottage has frequently proved cheaper than the stone cottage. There are, however, new factors to be considered : the question of transit, the great demand that there will be for bricks and bricklayers, the possibility that some of the ordinary demands for quarrymen and masons may not be able to be met immediately after the war, and, further, the fact that an unprecedented number of cottages will be required to be built in rural districts and in all parts of the country, all affecting the situation and suggesting the advisability of a fresh consideration of this alternative material in districts where it is readily available. Moreover, there has been a tendency in some districts owing to local custom to consider that a stone wall must necessarily be built in a certain manner, involving a considerable amount of labour and dressing of the stonework, whereas frequently a simple rubble wall or wall built with stones, only approximately coursed by hammer dressing, would provide ample strength and durability for the purpose of cottage building.

225. In some districts suitable lime for such walling is not available except at high prices ; it is possible, however, that local limes may be rendered usable by a suitable admixture of cement. This point is being further investigated. Enquiries are also being made into the various local methods of using stone which have proved economical and effective in the past, with a view to reviving the use of this additional building material in districts in which the new conditions will render it economical to do so. Some classes of stone will not readily form openings for wooden window-frames or other fittings ; in such cases standardised concrete frames could be built in and jointed up to the rough stonework so as to produce a strong and weather-proof junction. There are certain stones which, except when built in walls of great thickness, are not entirely weather-proof in all situations, and there are others which are liable to sweating or condensation on the inner surface ; possibly the lining of such walls with thin breeze concrete slabs may enable them to be used economically to produce a dry and comfortable house. These methods of building are well worth consideration in districts situated far from brickfields or far from any railway station to which bricks could be delivered.

SUBSTITUTES FOR TIMBER.

226. The second subject to which we paid special attention had reference to possible substitutes for timber. In view of the scarcity of timber and the possibility that adequate supplies at reasonable cost may not be available for some time after the termination of the war, and in view of the fact that timber constitutes one of the largest items in cottage construction, much attention has been given to the adoption of possible substitutes, which resolve themselves into the following :—

1. Concrete in various forms.
2. Hollow brick or terra-cotta.
3. Iron or steel.

227. Reinforced concrete offers an obvious substitute for structural timber work, but, as commonly used in the past, it has been too costly ; when used in the form of beams or floors, it has been generally constructed *in situ* and has involved the use of considerable quantities of timber for shuttering or centreing, etc. ; and evidence seems to show that adequate skill for safe and economical construction in reinforced concrete has hitherto not been widely available in connection with cottage building.

FLOORS.

228. We have examined a number of existing systems of floor construction in common use as substitutes for timber on account of being fireproof or possessing some other quality which justified their use, although more costly than the wood-joist floor, and have come to the conclusion after consulting various experts that to find an efficient substitute for such a floor the following points must be considered :—

1. Any floor requiring much wooden centreing would largely defeat the object in view.
2. The weight of the floor itself must be an important factor, as this weight has to be carried and reduces the margin for carrying useful load. The weight increases the labour and expense in transport and hoisting, and might involve increasing the strength of supporting walls.
3. If the floor is constructed of sections made at centres for distribution, the sections must be suitable for transport without injury and allow of easy handling.
4. Sound-proof quality, freedom from condensation, and undue transmission of heat and cold are desirable.
5. There should be facility for fixing gas pipes or electric-light wiring.
6. A floor of shallow depth is economical in that it saves the height of the walling.
7. It is desirable to avoid as far as possible the use of beams involving concentrated loads at special points unless considerable advantages were secured by such type of floor.
8. The floor must be of such reasonable cost that in view of the probable high price of timber and after making due allowance for economies or advantages consequent upon the use of the floor, it may prove more economical than the wood-joist floor.

229. It is possible that in the period immediately after the war the total amount of timber required for building may not be available. In that case we recognise that even if the best alternative type of floor should prove considerably more expensive, it might still be necessary to adopt it for a proportion of the buildings owing to the fact that sufficient timber for all the buildings could not be obtained.

230. In connection with ground floors it is easy to dispense with the use of timber. The only difficulty arises in connection with a substitute for boarding as a floor covering, but if no substitute equally good can be found, it is practicable to lay boarding directly on to concrete or on to fillets bedded in it provided that proper precautions are taken to secure that the concrete is thoroughly dry, and that any wood laid on it or bedded in it is protected from damp by a coating of bitumen. In regard to upper floors, however, the problem is more difficult ; it is obvious that such a floor is a structure with which no risks can be taken while much surplus strength cannot be allowed, as the weight of the floor itself forms a large proportion of the total load in most types of floor which appear practicable as substitutes for wood.

231. Having regard to the liability of timber to rot when used under the ground floor and to the desirability of covering the actual building site with a layer of concrete, we recommend that, for the ground floor, wood-joist floors should not be used in ordinary circumstances but that the under-floor should be filled up to a suitable level and covered with concrete (upon which the flooring material should be laid) so as to form a solid floor. The filling should be covered with a layer of dry ballast to avoid contact between the concrete and ground dampness. In such cases it would be sufficient to provide a layer of concrete 4 in. in thickness.

232. The use of standardised shuttering, etc., need not be ruled out altogether as these could sometimes be constructed from timber not suitable for better purposes, or from other materials. Where builders have no special experience the rolled-steel joist with plain concrete or concrete slabs laid in the flanges will prove the safest and most practicable substitute for wooden joists.

233. Of the alternatives requiring greater skill for construction and fixing, the hollow brick, tile or cement floor which has been so largely used in fireproof construction in the past, modified to provide for erection without centreing, appears to be the most promising type. As a means of dispensing with centreing, these blocks can be assembled into beams to form a section of the floor. The beams can then be hoisted into position and laid side by side, the joints being run in with cement or fine concrete combined with suitable reinforcement. A number of the different types of block and arrangements of reinforcement which have been suggested for this purpose are being tested with a view to ascertaining their relative efficiency and also the relative ease with which they can be constructed and erected.

234. The hollow brick has some advantages over concrete for floor construction ; it is lighter, offers more resistance to sound, is not such a good conductor of heat, and is not liable to expansion or contraction. Experience alone can determine whether it would be practicable to make floor sections at centres and to despatch them ready for erection by the builder. If the attendant difficulties could be successfully overcome and if each section when despatched contained the necessary reinforcement properly fixed and protected, it seems likely that the bedding and joining up of these sections might safely be left to the ordinary building contractor. If, however, this should not prove practicable, and the sections have to be put together on the site, it is probable that the work will be most safely carried out by specialists, and in that case the adoption of this type of floor would be practicable only in those cases where sufficient houses were being erected to make it worth while for a specialist to undertake the work ; in such cases it would be very simple for a few skilled men to construct the beams as the work progressed and, after allowing the necessary time for proper setting, to lay and joint them on each group of cottages as required.

235. In comparing the various methods of floor construction it is important to consider the following points :—

1. The thorough protection of the reinforcement.
2. The placing of the main reinforcement as near as practicable to the underside of the block.
3. The adoption of a form of jointing which will secure for the floor when erected the additional strength due to a homogeneous slab as compared with a series of beams laid side by side.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. The last article appeared in our issue of July, 1918.—ED.

Mesh Reinforcement.—*No.* 117,942. *F. E. Whitham, Standard Tool Company, Mearclough Works, Sowerby Bridge, Yorks. Dated August* 8/17.—This invention relates to reinforcement for concrete structures of the kind in which the reinforcement consists of flattened helices or coils intermeshed by longitudinal bars. The invention consists in indenting these longitudinal bars (*d*) so that the flattened coils (*c*) are positioned on the bars, as shown in *Fig.* 3.

FIG. 3.

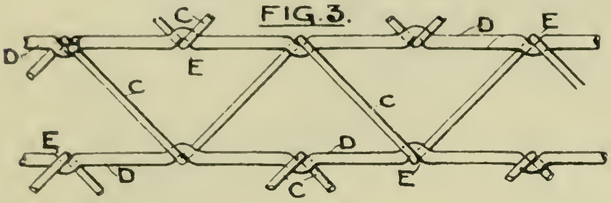
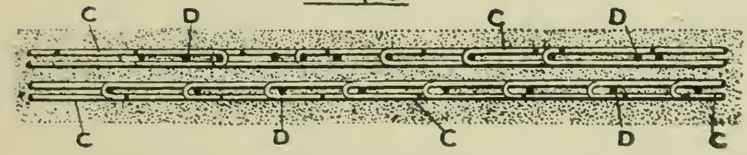


FIG. 5.



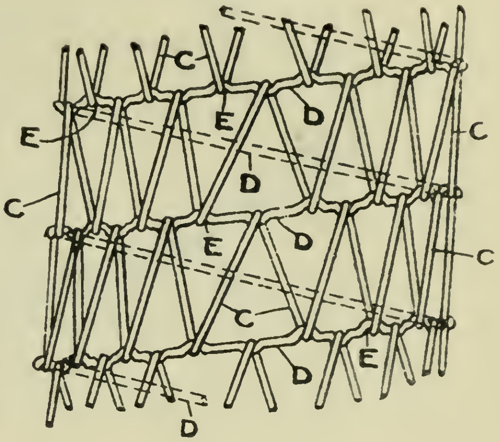


Fig. 7.

Two layers of reinforcement may be employed, as shown in *Fig.* 5, the angles of the coils crossing each other.

In the application of the invention to tubular bodies, the metal coil is wound upon a drum of the desired diameter and on completing one revolution, and the bar (D), *Fig.* 7, is then inserted in the space provided by the intermeshing helices. The coil is then continued by guiding this rod between each succeeding pair of coils. The steel skeleton is then taken off the coil and expanded axially, so that the coils become locked in the indentations.

Casting Reinforced Concrete Ships, etc.—*No.* 115,664. *J. P. R. N. Strover, 63a, Drayton Gardens, South Kensington, London, S.W.*10. *Dated May* 11/17.—According to this invention the sides of a ship or other vessel are cast in a horizontal position and are subsequently raised to final position after the concrete has set. In the case in which the vessel is built on a sloping slip-way, the slabs (*a*), with cross-ribs (*b*) and longitudinal beams (*c*) are cast on mould panels (*d*), which may be supported by wedges (*e*) on piers (*f*). To form the sides, hinged flaps (*g*) are temporarily hinged to the panels (*d*), and the side slabs (*k*), with cross-ribs (*l*) and beams (*m*), are cast in horizontal position, struts (*i*) being provided to support the flaps (*g*). When the concrete has set sufficiently, the flaps are raised to the required angle and bonding concrete is poured in the joints (*n*), between the bottom and sides, and also in the joint (*o*) between two adjoining units of the side panels. The ends (*p*) of the reinforcing bars are preferably of looped form and are interlocked by longitudinal rods, as shown at the joint (*n*), *Fig.* 1.

If the vessel is of the barge form, the sloping ends may be similarly cast on flaps (*w*) ; but if the stern and bow ends are of special form they are preferably cast *in situ* in the usual manner.

A number of launching trolleys (*s*) may be provided below the moulds ; when the slabs forming the bottom have set, the mould panels (*d*) are removed by loosening the wedges (*e*), and the trolleys are then drawn up to support the weight and are packed up by wedges. After the shuttering has been removed, the bottom slab may be provided with a suitable protective covering before the trolleys have been secured in position.

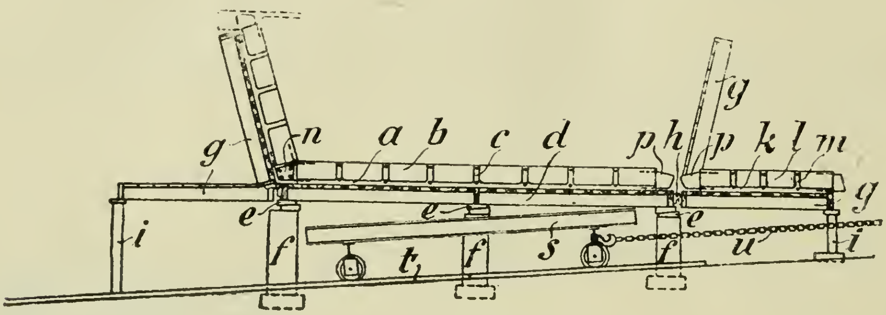


Fig 1.

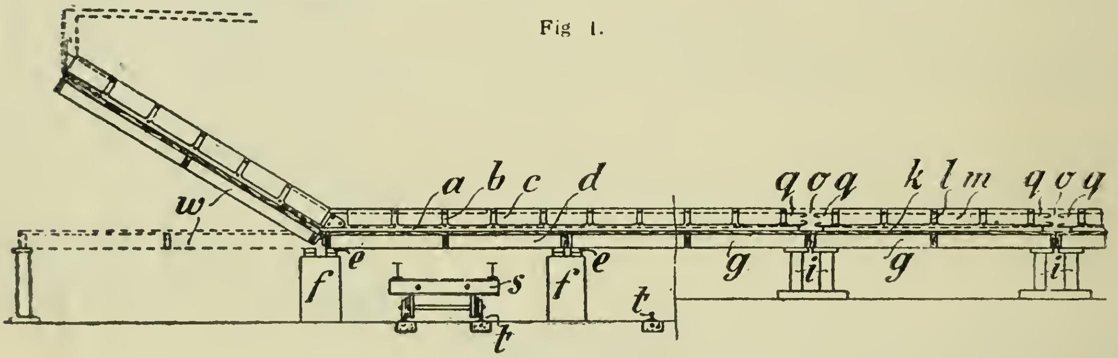


Fig. 2.

The invention is also applicable to the casting of a concrete vessel upon the concrete floor of a dry dock ; in this case the concrete floor may be treated with oil or covered with oil paper prior to casting the vessel, in order to obviate adhesion to the floor of the dock.

Cellular Concrete Structures.—*No.* 117,667. *E. R. Calthrop, Eldon Street House, Eldon Street, London. Dated July* 24/17.—This invention relates to floating concrete structures of the kind described in Specification No. 22,099 of 1910, in which the whole hull is composed of a number of juxtaposed cells, so arranged that each divides the vessel into a number of separate portions, which may be destroyed without impairing the floatability of the vessel as a whole.

According to the invention, the vessel is formed on the exterior surface with a number of longitudinal grooves in each of which is placed a reinforcing bar, vertical grooves being provided at appropriate intervals to accommodate vertical reinforcing bars, which are preferably formed with eyes through which the other bars pass After the longitudinal and vertical bars are arranged in position, the grooves are filled up with concrete and vibrated to make a homogeneous joint.

The intersecting grooves (*b*, *c*) are preferably provided on the inner half (*a*) of the hull of the vessel, and longitudinal reinforcing bars (*d*) are anchored to the concrete by twisted wires (*e*). Three forms of vertical reinforcing bars (*f*, *g*, *h*) are shown in

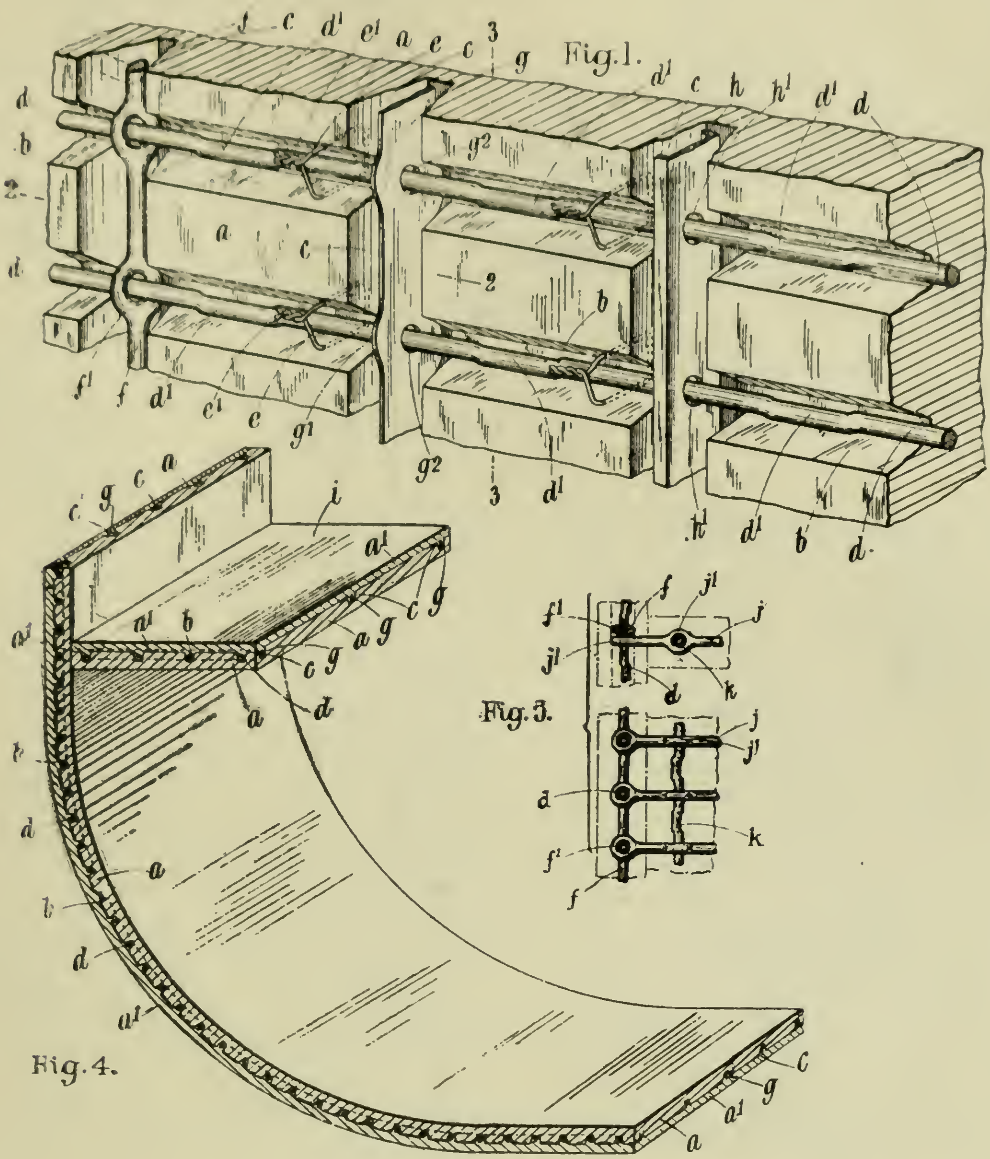


Fig.1.

Fig.3.

Fig.4.

Fig. 1 ; in one (*f*) a round bar is provided with eyes at intervals ; in the second (*g*) a flat bar provided with holes and offset portions (g^1) is employed ; and in the third (*h*), a channel section provided with holes at intervals is used.

Reinforcement for Concrete Ships and other Structures.—*Nos.* 115,695 *and* 115,797. *W. J. Stewart and J. Woolcock*, 42, *Albemarle Street, London, W.*1. *Dated May* 16/'17.—These inventions relate to the reinforcement for concrete walls of ships and other structures.

According to the first invention the outer shell reinforcement is made up of a double network construction ; the vertical or transverse members of both networks consist of parallel rods (*c*) and (c^1) of circular section following the contour of the transverse sections of the ship. These rods are held in position, preferably alternating with one another, by longitudinal reinforcements (*d*, d^1), which follow the contour of the horizontal sections of the ship and are twisted together between the vertical rods.

In this manner a completely linked up basket-form of reinforcement is obtained which is specially suitable for the curved contour of ship construction.

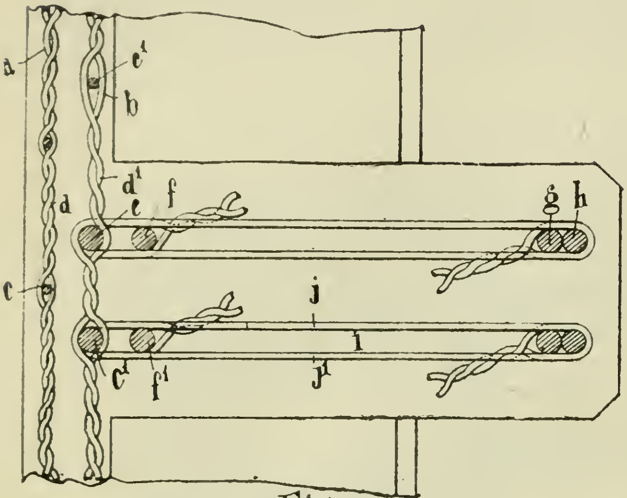


Fig. 1

According to the second invention, pairs of rods (*e, f, g, h*), forming the two elements of a group, are suitably spaced by means of loops (*i*), formed of two parallel pieces of wire (j, j^1), preferably of equal length and placed upon opposite sides of a group of rods. The ends of these wires are bent so as to encircle a pair of rods at each end of the group, the wires being then firmly connected by twisting together as shown.

Spiral Reinforcement.—*No* 118,236. *A. W. Storey, Ascendant Works, Wellington Street, Newton Heath, Manchester. Dated March* 13/18. According to this invention spiral reinforcement for beams, columns, pipes, etc., is formed in sections, with each end of each section terminating in a twirl or screw-shaped eye adapted to screw into the corresponding portion on the end of the next section.

The screw-shaped eye (c^1) of the section (c) is passed over one of the longitudinal reinforcing bars (b), and the wire (c) is wrapped specially with any desired pitch around the remaining bars, and at the end of the section wrapped around another longitudinal bar to form the second eye. The eye (c') of the next section is screwed into engagement with the former and the wrapping continued.

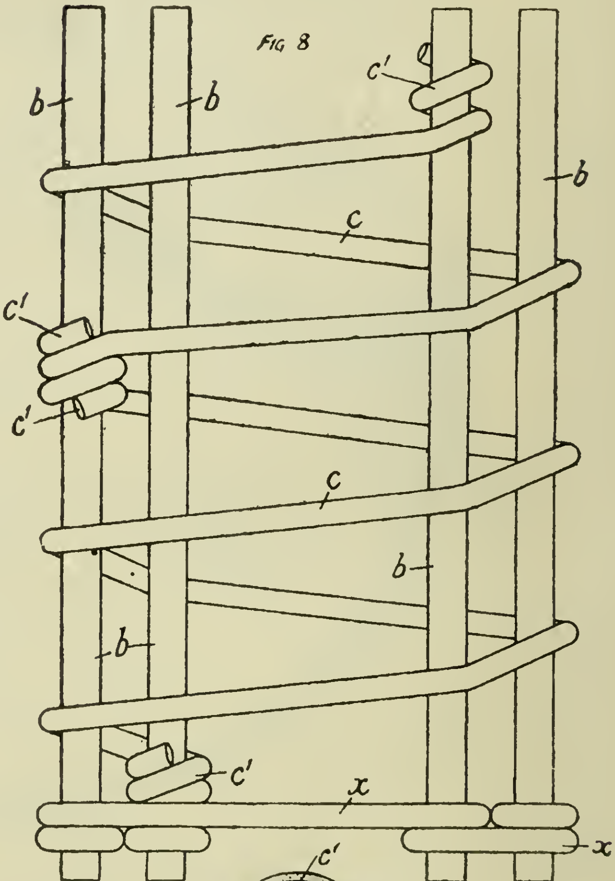


Fig 8

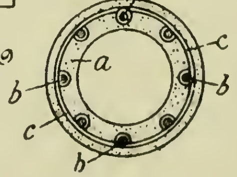


Fig 9

Metal Reinforcement.—*No.* 117,915. *J. H. Walker, "Eridge," Shooter's Hill, Woolwich, Kent. Dated June* 8/17.—This invention relates to metal reinforcement for concrete of the type in which a metal framework is built of longitudinal and transverse members combined with ties in the form of zig-zag bars. According to the invention, the zig-zag bars are pivotally carried at their lower angles in suitable eyes, transverse bars being laid near to the eyes. The main longitudinal bars are then laid crossways on the transverse bars between adjacent zig-zig bars, which are in pairs, and the latter are turned up or crossed over the longitudinal bars so that the latter are locked in position between the zig-zag and the transverse bars.

The eyes (b), acting as pivots for the zig-zag bars (a, a^1), are formed by looping the transverse bars c), so that the reinforcement is quite independent of the bed upon which concrete is to be laid ; but the eyes may be in the form of staples driven into the bed.

Fig 3

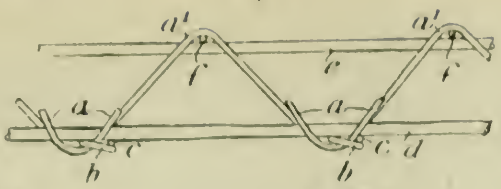


Fig 2

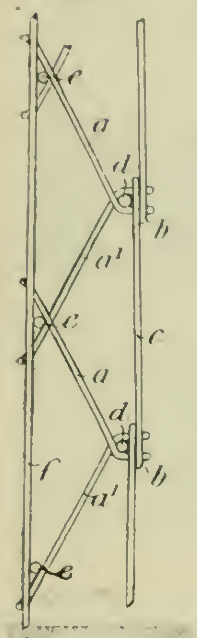
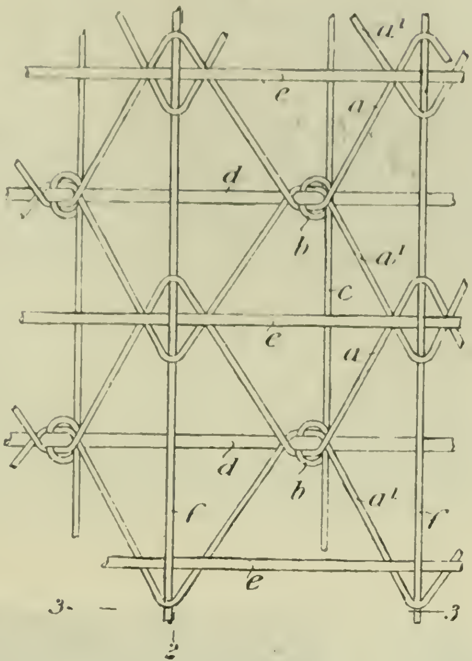


Fig 1



The main reinforcement bars (*d*) of the bottom layer are laid across the transverse bars (*e*) between the pairs of zig-zag bars (*a*, *a*¹), so that when the latter are crossed over the longitudinal bars (*d*) and the loops of the bars (*a*) or (*a*¹) are passed through each other, these bars (*d*) will be firmly locked in position.

The invention is particularly applicable, although not lestricted, to the construction of concrete roads and foundations.

Reinforced Concrete Ships.—*No.* 118,754. *Communicated by the San Francisco Shipbuilding Company to L. W. Goold, 5, Corporation Street, Birmingham. Dated November* 29/17.—According to this invention, reinforced concrete ships, having reinforced vertical and horizontal walls, with beams extending therefrom, are provided with two-part stirrups enveloping reinforcing bars of the walls and beams respectively.

The sides (1) and bottom (2) are provided with beams (3, 4), and the stirrups (9) are made of two separate parts, as shown in *Fig.* 4, and pass around the reinforcement in the manner shown.

The advantage claimed for the split stirrups in preference to the usual integral form is that they can be inserted at the sides after the main reinforcement has been placed in position.

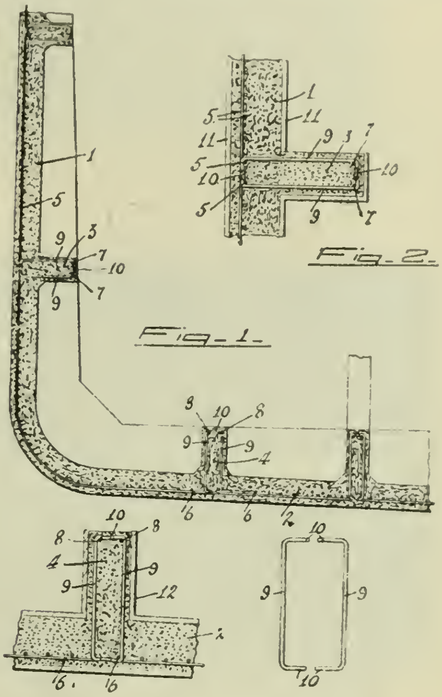


Fig. 2.

Fig. 1.

Fig. 3.

Fig. 4.

Grooved Bar Reinforcement.—*No.* 118,980. *J. T. McNay, 62, Northumberland Road, Old Trafford, Manchester. Dated February* 7/18.—A bar for concrete reinforcement constructed in accordance with this invention has three or more equally-spaced grooves (b^1, b^2, b^3), with interrupted portions (*i*), the shapes of the grooves being so determined that they can be made by one pass through finishing rolls.

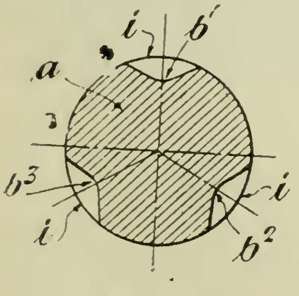


Fig. 3.

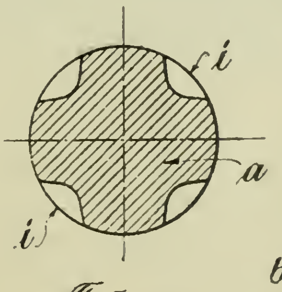
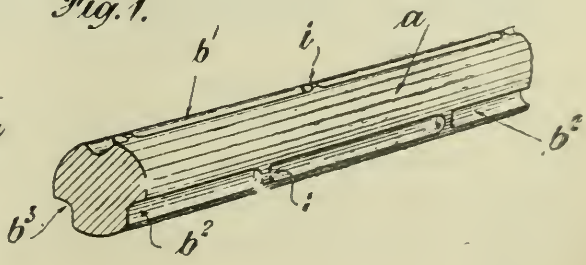


Fig. 4.

Fig. 1.



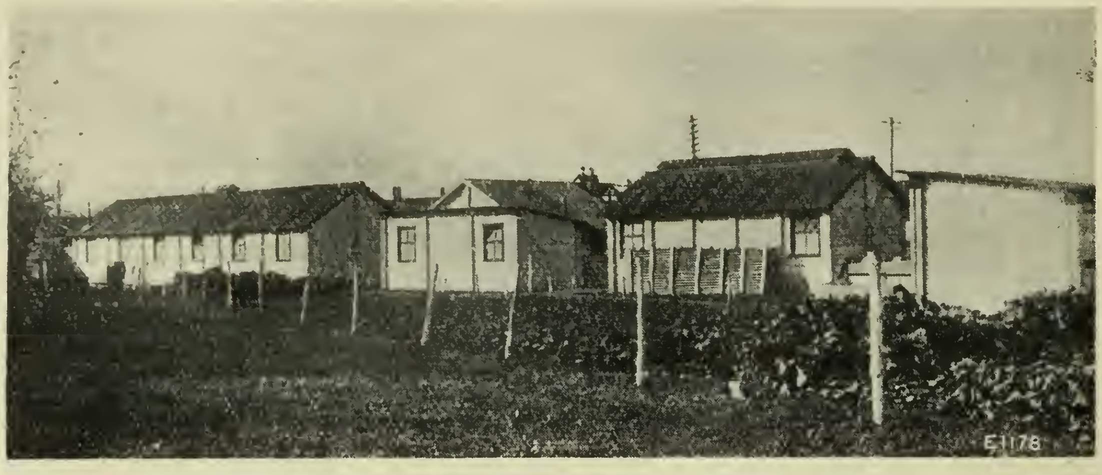


Fig. 1. Some Light Buildings in France Constructed of Chalk Concrete Hollow Blocks.

CHALK CONCRETE

In the March issue of this journal last year reference was made to a form of concrete block construction invented and carried out in France by Capt. Quick, R.E. Since that time a great advance has been made in this type of construction, blocks of different forms have been employed, and the product has been applied to a variety of uses.

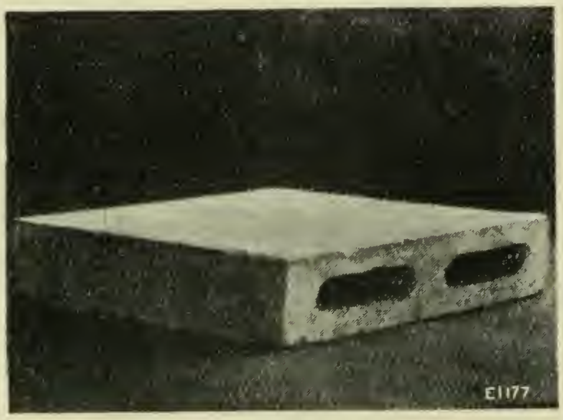


Fig. 2. The "Quick" Chalk Concrete Hollow Block.

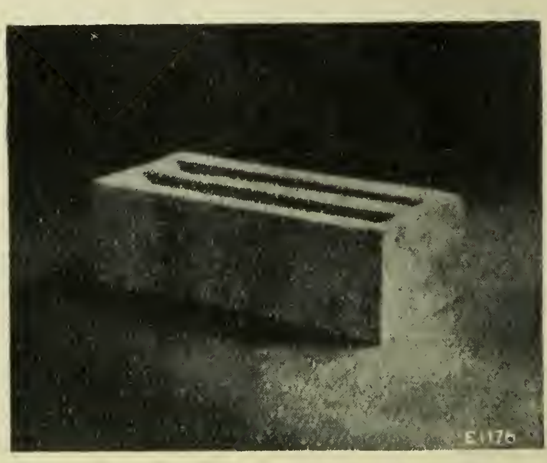


Fig. 3. The "Quick" Chalk Concrete Solid Brick.

In this system, it will be remembered, the concrete was composed of chalk and Portland cement. The original block intended for walls of the pier and slab type was hollow and measured 10 in. by 10 in. by 2 in. A photograph of this is shown in *Fig.* 2. The composition of the concrete, both for piers and blocks, is one part Portland cement and four parts chalk. The chalk is first thoroughly ground in a mill, and then the proper proportion of cement ground in with it. The mixture may then be made into a slurry, poured into moulds and allowed to set; or it can be moulded in a substantially dry state under pressure when it is said to be ready for use almost immediately.

In addition to the hollow blocks, which are used in two sizes, 10 in. by 10 in. by 2 in. and 9 in. by 9 in. by 4½ in., solid concrete bricks are made, as seen in *Fig*. 3, 9 in. by 4½ in. by 3 in. These are moulded with the aid of a French hand press, the mixture being in a semi-dry state, and variously proportioned from 1 : 4 to 1 : 10. It is claimed that the concrete bricks thus produced, and in the manufacture of which unskilled labour only is employed, are equal to the best facing brick made in this country, and at a cost well under that of the cheapest burnt brick. The buildings in the erection of which these blocks have been

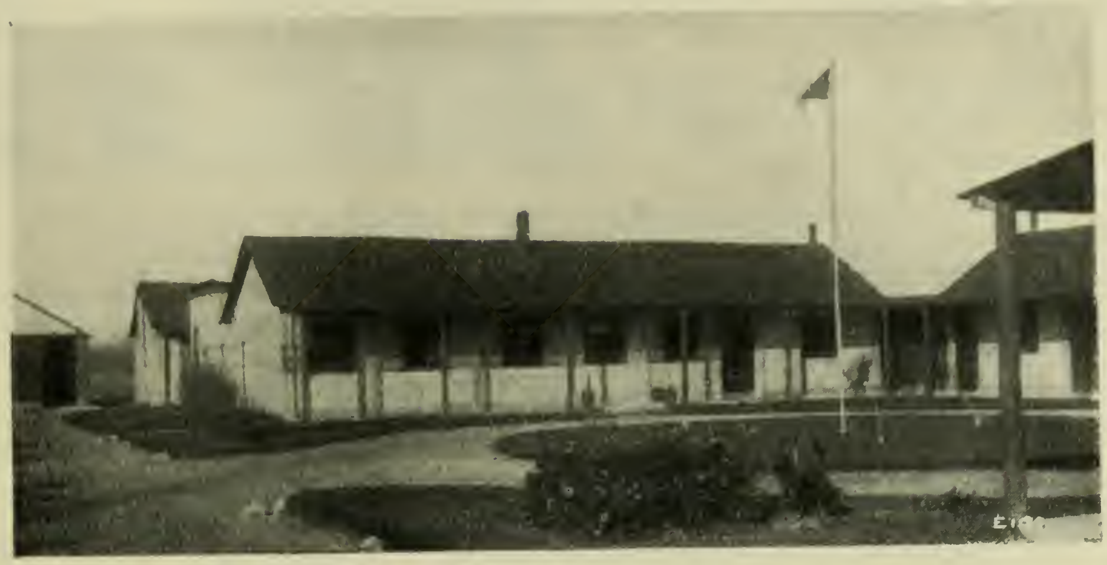


Fig. 4. Headquarters Buildings in France.

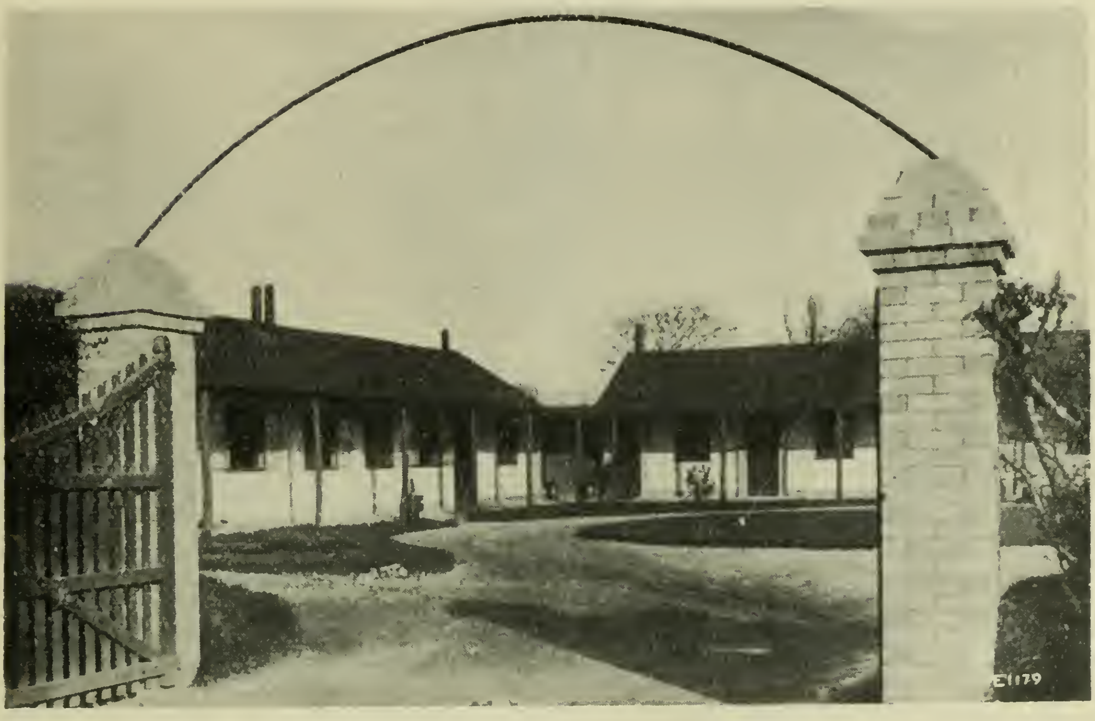


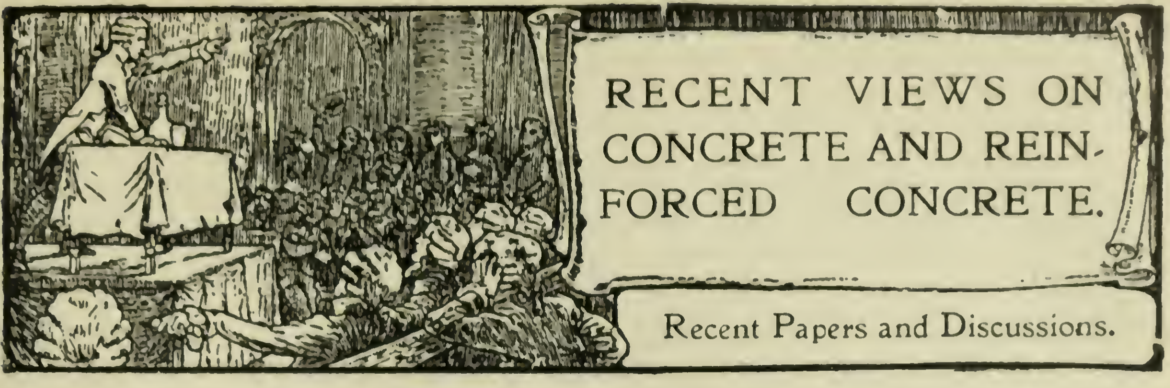
Fig. 5. Headquarters Buildings in France.

used have withstood the rigours of three winters, and we understand have shown themselves to be unaffected by frost or rain ; experiments, too, have been conducted with a view to ascertaining the fire-resisting properties of the material, which, we are informed, were found to be very high.

As would be expected from the nature of the ingredients, this kind of concrete has a very fine texture, and it is said that when green it can be carved with ease.

Since concrete of this description is something of a novelty, it has naturally attracted a great deal of attention in France, where the idea has been developed, and the buildings, a few of which are shown in the illustrations, have been subjected to close inspection. *Fig.* 1 is a photograph of light military buildings, and *Figs.* 4 and 5 the headquarters of an officer of high rank.

At this period, when the shortage of bricks is acute, and the need for buildings of all descriptions is pressing, the production of what practically amounts to a new building material cannot fail to be regarded with interest.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE ÆSTHETIC ASPECT OF CONCRETE CONSTRUCTION.

By C. F. A. VOYSEY.

The following is an abstract from a paper read before the Concrete Institute on December 19*th*, 1918, *and we also give a short report of the discussion which followed.*

INTRODUCTORY.

THE conservative instinct in some of us tends to strengthen our prejudices. And a fondness for hand work and the qualities of familiar building materials make one shy of the mystical concoctions that are more or less mingled with brains. Concrete seems one such that depends on conscience. The man who mixes the material must exercise his conscience, and who can measure the amount or tell its value ? A brick seems more frankly to proclaim its qualities, and as with stone and timber, we know from past experience all that it can do for us. But concrete is an unknown quantity to many of us, except perhaps when used in its simplest form, as for foundations. Another element of my prejudice is due to the recollection that greed is gratified by the use of concrete construction. That is to say, the shopkeeper who is out to make money wants to seize every inch of space. He thinks the display of his wares is better for him the more vast it is. Beauty has no charm for him and quantity is of more value than quality. Concrete construction has helped in this direction. Meanness and greed I say are its parents. What can be expected from such an ancestry ?

Besides the great difficulty experienced in making alterations to buildings so constructed, we find the greatly enhanced sound-conducting quality often very troublesome. And, lastly, the imitative instinct in man has found abundant scope for its expression when making use of this form of construction. Buildings are made to look like stone or brick, and even at times like half-timber work. Deception gains eloquent expression in this material.

We usually find, when any new inventions first appear (like the railway train or the motor), they are made in the form of that which they are destined to replace. The evolution of things is quite evident to us all, so we may look forward with confidence to the time when concrete construction will have a character of its own and will cease to be made to look like anything that it is not.

We shall all agree that the finest examples of building throughout the wide world have been the result of the consideration and understanding of the requirements and conditions obtaining at the time of their creation, and of the moral, intellectual, and spiritual character of the people of their time and place. When these considerations have been neglected, and partial knowledge of foreign examples has fascinated us, then our architecture has become corrupted and exotic.

Therefore it follows, as the best work grows out of requirements and conditions, it is from requirements and conditions that the character of concrete construction must be evolved.

CONCRETE AS A BUILDING MATERIAL.

As the conditions for concrete are quite different from those for stone, brick or timber, the mode of its expression must be different. Doors and windows are requirements, but the form they take must depend on conditions. Those conditions are chemical, substantial, and functional. The ingredients of which concrete is made have their distinctive qualities, and any scientist could write a book full of facts concerning these things.

But beyond all this knowledge of conditions we have requirements equally innumerable and various. *What* do you want to build, is no more important a question than *why* do you want to build ? After all the knowledge of material requirements and conditions has been gathered together and classified, we shall find all this knowledge worse than useless, until we bring to bear upon it the moral, intellectual, and spiritual sides of our nature.

Concrete, like our coat, may cover many useful appliances, but is useless without the soul within it. We cannot help conveying a spiritual something to everything we create.

The unseen is the glory of the seen. The cathedral speaks to us, and the heavens declare the glory of God. Man is born to be a creator ; and as Nature is bursting with songs of praise, audible to all who will listen, so man must make his works shout with joy, and stimulate our higher nature through ministering to the spirit.

It is no use to tell me engineering is not an art. For I tell you Art is only the manifestation of thought and feeling, and it is not only possible but essential to us all. We cannot live a day without it, though many know it not. There is in everything a spiritual something, that appeals to every human heart that will listen and look So with your concrete or your marble, the heart of man may be made to rejoice.

Bad workmen find fault with their tools, and as concrete is in a sense one of our tools, we must not quarrel with it ; though doubtless some will quarrel with my simile and say a tool is the instrument by which something is created, whereas concrete is the creation itself. Now this is a great fallacy. Concrete in itself is an ugly thing. But concrete construction considered as a servant and as means to an end can be made a ministering angel. It is a good servant, but a bad master. A good servant, only so long as it is kept in its place. There are many kinds of buildings which, it could be argued, would be more suitably constructed in concrete than in any other material But there are other kinds for which concrete would be most unsuited. It is therefore necessary to admit the unique character of concrete in order to use it fittingly and artistically.

PROPORTION.

We shall surely all agree that proportion is of vital importance to the subject in hand. The sense of relation is only another aspect of the sense of proportion. It enters into all the affairs of life and into all our calculations of fitness. It is the manifestation of personal character. Every man's sense of proportion varies as his character varies, and is unlike all other people's sense of proportion quite as much as his character is unlike and is the very essence of personality. This lovely provision of diversity is a godsend. It makes everyone feel that in matters of beauty there is no finality, and that everyone is entitled to hold his own views as to what is or is not beautiful and praiseworthy. And in contemplation of the details in human existence, from the smallest to the greatest. we find the sense of proportion constantly being appealed to. No less then is it a fundamental quality in all our buildings.

It is my firm conviction that the beauty of concrete construction must mainly consist in right proportion. What are right proportions ? Each must ask and answer for himself. I refuse to have any formula forced upon me, either Greek, Roman, or Gothic. It is a matter of feeling and is capable of refinement, for ever evolving and developing as we advance in spiritual, moral, and intellectual culture. We want no dogmatic statements of what is in good proportion any more than we need a definition of truth or beauty. All are growths, for ever being purified and lifted higher.

It is quite true that the Greeks arrived at what we regard as perfect proportion, but it was perfection as applied to given objects. Definite groups or requirements and conditions were beautifully proportioned, but to copy these proportions in designing the portico of a public-house is like grasping at the shadow and forgetting the substance.

Those who are steeped in archæology cannot glorify concrete construction. Precedent and ancient fashions will not help us here. Man is born to develop his character and new modes must be evolved for new materials. We have all the faculties for the purpose, if we will only exercise them.

Descartes said: "The more we concentrate attention on the past, the less we shall understand and appreciate the present." So to make the best use of concrete construction we must divorce ourselves from the past modes of architectural expression and try to enter into the spirit of our new material, and to dominate it with that which is highest and eternal in our nature.

Men with delicate feeling will express beauty through any medium; and provided they are not hide-bound by tradition, they will create that which breeds beauty of character. In this life there is no higher calling.

There is one thing for which we must be thankful to concrete construction—namely, that it has forced upon us the necessity for a revision of the building by-laws. These foolish and mischievous irritations must be revised, if not repealed altogether, for the stupidity of veneering concrete construction so as to give it the appearance of stone is fraudulent as well as foolish. Veneer, when frankly applied, is legitimate enough, but it is open to question as to whether a concrete building cannot be made beautiful and satisfying without veneering it all over. The texture of concrete might be made as pleasant as stucco. It is quite doubtful whether we should allow the expenditure on veneer, the purpose of which is purely and only to enhance appearances. True architectural beauty, to my mind, must be wedded to structural function. Therefore the form of your concrete and mode of its use must embody elements of beauty, and not depend for its charm entirely on superimposed material of quite another nature. This suggestion can only be applied in certain cases, and is not a principle of general application. It should not be used as an argument against mural painting or mosaic. It would surely be quite possible to put up a concrete building in good proportions with the concrete walls exposed to view in naked frankness and wedded to certain features of stone or native marble. The main entrance of such a building, having an heraldically carved surface above, richly coloured and gilded, would surely be a quite legitimate treatment.

The most difficult branch of this subject would seem to be suggested by the question, How far may we, for the sake of calling up association of ideas, use the arch form?

We cannot deny that the Gothic arch has a profound effect on our minds and hearts, and is structurally the practical outcome of small stones and bricks. The lintel would seem, structurally speaking, the most suitable form for concrete construction. The four-centred arch of Tudor times can be easily made in concrete, but it is surely much more complex than the lintel. The slightly pointed arch is so dear to me that I want to modify and limit all my principles to admit it. Like all weaklings, I wish to be sound and logical, but pure feeling, which enemies sneer at and call sentiment, gets possession of me and carries me off into the clouds. We love to appear intellectually great and scientifically sound, but not at the expense of all human emotion. This little touch of inconsistency, this human frailty that abandons itself to pure emotion, is one of the most human of all human charms, and thus it comes about that it is the unseen that is the glory of the seen. The emotion is buried beneath matter, not to rot, but to regenerate.

The rank materialist, the atheist, and the scientist are, thank God, one and all human, fallible, and loving. Otherwise we should want to crucify them. These same qualities are what make life so interesting and stimulating. Therefore I say you *must* mix them in your concrete construction if you have a spark of love or regard for your fellow-creatures. The desire to give rather than to get, which is the mainspring of all creative energy that is beautiful, must make us study fitness in order to serve well. And by this careful study of requirements and conditions, and by fidelity to all that we think beautiful and true in human thought and feeling, we shall, I think, be able to evolve a mode of concrete construction as unique and personal to the material as any stone-constructed building that was ever created. And for this purpose the less we are familiar with foreign or ancient styles the better.

DISCUSSION.

Mr. F. E. Wentworth-Shields, M.Inst.C.E., after thanking Mr. Voysey for his most thoughtful and inspiring paper, said that to one who was purely an engineer his ideas had been most helpful. Such thoughts as those expressed in Mr. Voysey's paper reminded them that architects had been enormously helpful to engineers during the past half century. When railway construction began, the designing and erection of large and important buildings had been almost mainly in the hands of men of great scientific attainments and of experience in difficult forms of construction, but with no experience in æsthetic design of any kind, and the result had been that they had undoubtedly got some very large and important but hideously ugly structures in the country. He could almost wish that it had been possible for Mr. Voysey to have illustrated his paper with views showing what might be done in concrete construction. He would like to ask Mr. Voysey whether he did not think that the French people had a peculiar aptitude for evolving good construction out of new material. It had seemed to him that when steel construction came in, the bulk of the English designs were certainly far from pleasing, whereas the French had very quickly adapted them, and made an architecture out of them which had been far more pleasing than the British steel construction, and although reinforced concrete construction had been with them such a short time, the French had done better than they had in that way. He would be inclined to study French design in reinforced concrete, not with a view of imitating them, but with a view of getting inspiration from them in their methods of overcoming the very difficult problem of adapting what Mr. Voysey had perhaps rightly called ugly material, and making of it something that was not only useful but pleasing.

Mr. Francis Hooper, F.R.I.B.A., said that engineers had at times in their structures felt that their work was incomplete, that something was wanted either to cover it up or to disguise it. There must recur to the mind of everyone of them engineering structures pure and simple which were the embodiment of art, which satisfy the mind in every way. What could be more impressive than the Forth Bridge, which, he believed, had no ornament of any kind. He thought Mr. Voysey might have had something to say on the problem which was almost uppermost in their minds, the problem of housing the people. He asked those who were making this problem of material their life study to go on with experiments. It seemed to him that some of their problems might be met by the use of the material they were then discussing. When one saw the likeness in which the doors, staircases, window frames, etc., all sorts of things can be made, how ingeniously they seemed to lend themselves to standardisation, he believed that was going to be the solution of the economic side, not to have hundreds of men in hundreds of places working out their own details. Unfortunately, they saw the buildings were in their wrong places, very frequently turning their backs to God's light, frequently with the wrong aspect, constantly with the wrong prospect, constantly at the wrong level. It seemed to him that they would do something to serve the country if they could make these problems an occasional study, and help those who were really taking to heart the problem of housing.

Mr. Ewart S. Andrews, B.Sc.: Mr. Hooper had said several things which he (the speaker) was glad to hear from an architect. As a scientist he thought they ought to lay it down practically as a law that a thing was beautiful if it fulfilled its function efficiently, and if things appeared ugly to them when scientific experiments had shown them to be right, then what was wrong was not the thing but their sense of beauty. He was sure if the artist was willing to accept that dictum and to join hands with the engineer, they would in the next century get very much better results than they had got in the past.

With regard to the question of standardisation, his artistic friends had pointed out to him the fact that the great objection to engineers was that they made everything alike. If the architects were willing to withdraw that accusation, they would all very much benefit.

Mr. W. J. H. Leverton: Mr. Voysey had said that concrete in itself was an ugly thing. Did not that depend upon the form in which it was cast ? It might be cast in a beautiful form or an ugly form.

Mr. Voysey had spoken of proportion being the manifestation of personal character. He did not think they could quite agree to that. The Greeks, for instance, had ideas of proportion which had been arrived at after generations of experiment; there was not much individuality there ; it was the result of centuries of trial. He thought everyone would agree with Mr. Voysey that the beauty of concrete construction must mainly consist in right proportion. They must have right proportion first, and ornament afterwards, if funds would allow.

With regard to archæology, it was not given to everyone to be original, and if a man could not be original to some purpose, he thought he had better follow something which was good rather than originate something which was bad.

As to the form of concrete buildings, it had been said that all reinforced concrete buildings should have thick external walls, otherwise cracks would result. If they had thin walls they were bound to have cracks, owing to the difference between external and internal temperature. and it was thought desirable always to have brick walls. But authorities differed on that point.

As to the question of arches *versus* lintels, Mr. Voysey considered that the lintel was the most suitable form for concrete construction. Was that really so? In an arch they could do with very little reinforced concrete, and then, of course, the structure was much more durable.

Mr. Noel Ridley, M.Inst.C.E., said when they looked round at some of the rather extraordinary structures that they saw sometimes, it was time they should consider this point of artistic effect combined with structure more carefully. There was too much idea of putting filigree work or some type of ornamentation and forgetting that comparatively little ornamentation was necessary. It might be that they sometimes did not copy the Greeks as they should, but when they saw a design of a number of columns close together, of large diameter, supporting a flat roof of short span, surely that could not be an æsthetic structure. Those columns should be strong enough to take any load they want to put on, while as a matter of fact the load was practically nil. The first consideration was utility, then they could see how it was possible with the materials employed to obtain an æsthetic design, and then to put on only the amount of ornamentation which was necessary, not to overpower it in that direction.

A good deal had been said about the artistic design of bridges.

He quite agreed that the less ornamentation they had in bridge work the better. It did not matter what material they used, whether reinforced concrete or steel; the arch type was certainly the more artistic, and the arch type could be made stronger than almost any type of construction.

THE LECTURER'S REPLY.

Mr. Voysey, in reply, said he had been very much struck by the speakers' comments on his paper Mr. Wentworth-Shields had suggested that he should have illustrated his paper. That, he thought would have been monstrous impudence.

Individual character would always make a difference in a man's work, because they could not all feel alike and think alike.

He had not seen modern French concrete construction, but he could readily believe that the French would be quicker at grasping the character of it, because it seemed to him they were rather more emotional than the English, and it was that emotionalism which had enabled them to grow into the spirit, as it were, of the new material. The French were not dominated, so much as they were, by a hard intellectual scientific outlook. If, when they were asked to do something, they considered why they are asked to do it, what were the conditions under which they were asked to do it, they might leave all the rest to their own character. They need not go to the Greeks or the Dutch. or the Chinese, or anyone else. They all had it in their own nature.

He thought all good architects recognised the enormous help that the engineer had been to them in discovering fitness. Fitness was really the basis of all art. It was the scientific mind and the engineering mind, and the very exact mind that really was after the truth all the time that was really useful. They began their training at the wrong end of the stick. They began to learn designing before they learned the material they were designing in. The engineer had been a very great help to the arts.

He thought that they might very reasonably standardise doors, windows, fireplaces, and internal arrangements, but he did not want to contemplate a standardising plan, which should surely grow out of the conditions of the site, the aspect, the land, the proportion of trees, the background, the local material, and so forth, all according to the arrangement of their plan. For cheap, economical building he could not see why they should not standardise doors, windows, etc., on one internal footing.

DESIGNS AND INDUSTRIES ASSOCIATION.

CONCRETE AND HOUSING.

We give below a short account of an interesting paper read on this subject by Dr. Oscar Faber.

INTRODUCTORY.

At a meeting on the 17th inst. of the Design and Industries Association, held at No. 6, Queen Square, W.C.1, a discussion took place on "Concrete in Relation to Housing Schemes," the subject being dealt with in a paper by Dr. Oscar Faber, on "The Use of Concrete for Cottage Construction." Mr. F. Anthony White, Chairman Associated Portland Cement Manufacturers, presided, and there was a good attendance.

Dr. Faber said that the use of concrete for cottages in the past had had for its object to effect an economy in construction in localities where ordinary building materials could not be obtained at a reasonable cost. The result was that concrete cottage construction hitherto had been used on the very plainest work only, and that partly accounted for the fact that the results in many instances had been far from beautiful. The special circumstances of to-day which justified a careful enquiry into the possibilities of concrete cottages were that, on the one hand, the demand after four years in which building had been stopped had grown to an unprecedented degree and become a pressing need ; and, on the other hand, the supply of ordinary building materials had fallen to so low a figure as to be only about one-tenth of the normal stocks. Having described in detail the properties of concrete and its method of manufacture either by " wet mixing " or " semi-dry mixing," Dr. Faber laid down the following forms of construction for walls suitable for cottage construction : (1) 9 in. brickwork, waterproofed outside with really good rough-cast or rendering, and plastered inside with common plaster ; (2) 11 in. brickwork with a 2 in. air-space, without rough-cast and plastered inside with common plaster ; (3) 9 in. concrete walls made by the semi-dry process, rough-cast or rendered outside and plastered inside ; (4) a double wall, consisting of 2 in. wet mixed concrete on the outside and of 2 in. dry mixed concrete on the inside plastered, with variations in that the inside wall might equally well consist of hollow tiles plastered, or of plaster on expanded metal, or even on laths.

SOUND RESISTANCE.

The question of sound resistance deserved attention. It was undoubtedly true that solid concrete walls carried sound vibrations more easily than walls built of soft brick in soft mortar, though a brick wall of hard bricks in cement mortar was nearly as bad. That was a very important question, since few things were so annoying in small houses as to be forced to hear in one room everything that was happening in the rest of the house. The difficulty was best overcome by the construction of double walls, both surfaces of which might be quite thin, and from that point of view there was no doubt that a construction of 2 in. dense concrete on the outside and 2 in. porous concrete or other material on the inside covered with common plaster, would be superior in respect of sound resistance to many cottages which had been built in brickwork.

EXTERIOR TREATMENT.

Discussing the important matter of appearance Dr. Faber said they were faced by a very real difficulty, in that their standards of beauty were determined, or very largely so, by what they had been accustomed to, and while their eyes had the experience of many centuries of brickwork, concrete was comparatively new. What was quite certain was that of all courses possible under the circumstances none could be so objectionable as the attempted deceit of making concrete resemble as much as possible stone-work of various kinds. No good could come of that ; it was a policy of faintheartedness. A perfectly legitimate treatment of exterior concrete surface was white or tinted distemper. In his opinion nothing was so dignified and pleasing as a perfectly plain wall surface with the windows carefully arranged and placed and the whole surface treated with a white finish. Provided the centering had been carefully arranged, personally he would not desire to have the board marks on the concrete resulting therefrom hidden or obliterated in any way. On the contrary, they should be made to give the work a certain character which might add to its appearance, and that treatment was obviously the most honest one, and would, he believed, in time, be found to be most pleasing to the eye when it was trained.

STANDARDISATION.

Proceeding to refer to the question of standardisation, Dr. Faber said it was important that windows and doors should be severely standardised, and it was most desirable that the standard sizes should be so chosen as to fit in conveniently with the standard size of concrete blocks, which might now be taken to be either 16 in. or 32 in. long. That reduced the cutting of special blocks to a minimum, and need not involve any loss of accommodation or appearance in the hands of a capable architect. It had been shown most conclusively in the war that shells costing 30s. to manufacture in small quantities could be made for 15s. on a large scale, and exactly the same applied to the construction of windows, doors, and small fittings if those could be severely standardised. The same applied very largely to cottages as a whole. He did not, of course, mean to suggest that there should only be one plan of a concrete cottage, which should receive the sanction of the Government and be erected everywhere. Nevertheless, having regard to the cost of the moulds and the very great saving in effort and cost which standardisation would effect, he did suggest that, where a self-contained town or village of some 400 or 500 houses had to be built in concrete construction, two or three types should be definitely settled and a hundred or two of each kind constructed. The objection that might be raised against that was that the result would be monotonous. Whether that was so or not depended very largely on how it was done. Of course to have a long, straight row of exactly similar cottages abutting one another, such as one saw in all large towns at present, was hideous, especially when each of those cottages presented some external feature indicating that it pretended to be a small mansion in miniature, and that feature was produced all down the line. A quite different effect could be produced by a large number of cottages carefully laid out in separate blocks at some distance from each other, following the natural contours of the land, with gardens between, and arranged in such a manner that some stood forward more than others. With skilful planning of that kind and provided the treatment of the cottages be kept as simple as possible, it was perfectly possible to reproduce even a single type of cottage over and over again without producing any feeling of monotony, since each house would have a slightly different aspect from the others, and would be differently placed with regard to its neighbours, and its garden would probably be laid out quite differently. The saving of human effort involved by standardisation of that kind was so real a factor that certainly at the present time it ought not to be neglected. It might easily result in reducing the cost of the cottage from £600 to £400, or whatever the figures might be. A very real temptation with concrete construction lay in the fact that ornament could so easily be cast by a mould to be used over and over again. Herein lay a real danger which must be vigorously resisted. Nothing could be so hideous as a large number of cottages on which some cast ornament was repeated on every cottage. The essential point in the matter was to keep the construction as simple, plain, and straightforward as possible. When that was done, and deep overhanging eaves were provided and the lines were right, he was perfectly convinced that a cottage could be repeated many, many times without objection.

THE USE OF COLOUR.

The use of colour, honestly applied, appeared to him, however, to be perfectly legitimate, and he thought great things could be done with it. Another matter he would like to see considered in the future was the painting of designs and frescoes in cottage work, it being understood, of course, that all work should be done by hand and not repeated on any two cottages. He was sanguine enough to believe that in the hands of men of taste great things could be done in that direction, legitimately and with considerable artistic effect.

CONCLUSION.

In concluding, Dr. Faber said an important matter was the abolition of the present restrictive bye-laws which prohibited construction which had not been sanctioned by centuries of use. If it could be shown that a satisfactory cottage could be built with walls less than 9 in. in thickness now that stronger materials were being employed, and provided care was taken as to ventilation, and heat, and avoidance of sound and damp, he regarded it as a vexatious and vicious policy to prohibit such construction. As to how cottage construction should be undertaken, some engineers had made an extensive experimental study of concrete from every possible aspect and possessed a wealth of information concerning the properties of the material which ought not to be neglected. On the other hand architects had a tremendous experience of economical and comfortable plannings and of the design of pleasing and simple lines and the correct placing of blocks of cottages or of isolated cottages in regard to one another. The only rational method by which all that experience could be used to produce the most perfect result, was for every individual architect dealing with the matter to join

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hands with an engineer experienced in that particular class of work. In that way only would concrete cottages be built which would be completely satisfactory to the tenant, the tourist, and the taxpayer.

DISCUSSION.

Mr. H. Fletcher (President of the Architectural Association) said that as an architect whose work had lain very little in the direction of concrete, he (Mr. Fletcher) had a good many problems to suggest and hardly any solutions to give them. Setting cottages aside for the moment, it seemed to him that the special qualifications of concrete as a building material—he was speaking of reinforced concrete—was for such works as bridges and piers in the sea—works which had to carry live loads, and where the expression they asked for was that of elasticity combined with strength· Concrete, in his opinion, was much preferable to steel for works of that kind, because of its resistance to the weather and corrosion, which called for little upkeep. Now they had found a material like reinforced concrete that had those weather-resisting qualities, it should be adopted at once for all such kinds of work. On the other hand, in buildings of what they might call the ordinary kind, which mainly carried dead loads, the expression of stability was very satisfying to the mind, and that called for a certain massiveness. Such buildings as churches and public halls, where there was no depth in the recesses could not give any impression of eternity, which was one of the highest means by which the buildings of the past impressed one. In such buildings as those he thought everybody must agree that the highest kind of admiration could not be produced, by dexterity. There were many difficulties in the use of concrete for building, most of which Dr. Faber had referred to. One difficulty was the jointlessness of the material, which was apt to show cracks which were very disfiguring when there were no joints to attract the eye. He did not think it was possible to prevent cracks from appearing in concrete buildings. On the whole he thought they might say that cement buildings looked best when they were quite new, and they had a tendency to gradually become shabby. Treatment with distemper or paint got over the difficulty, but it was a continual expense, and, as a rule, one preferred to build with materials which were their own justification, which were the same all through, and which had their own face. Buildings of good brick and stone, unlike concrete, were not at their best when they were brand new, but they improved every year. It would be interesting to know whether anything could be done for colour in cement, apart from colouring it with a wash. The colour of Portland cement in itself was cold and negative, and age did very little for it. It softened very little with weather, and very little vegetation grew upon it. When they were dealing with large engineering works, such as bridges, that point was of less consequence, because the structure was seen from a long way off, but for street buildings and cottages, which were seen quite close, the matter was very important. He would be glad to know whether it was possible in the mixing of concrete to mix in materials which would modify the colour without modifying its other qualities. Dr. Faber had dealt with the hardness of concrete in domestic buildings very exhaustively and most satisfactorily. Personally he (Mr. Fletcher) had a great dislike of hollow walls. They were often unavoidable, but they needed a great deal of watching in the construction. In connection with concrete cottages or domestic buildings generally, they lost the use of the walls as places for growing fruit trees and creepers, on account of the hardness of the wall, into which it was impossible to drive a nail. On the other hand ivy would cling to concrete and would do no harm to it. The conclusion he had come to was that concrete was suitable for certain kinds of buildings, and certain parts, and less suitable to others. It was their business, in dealing with a material which had such an immense future before it, to find out what those uses were, and to restrict it to them. Let them use concrete in suitable places and in a suitable manner ; let the material be their servant and not their master.

Mr. P. J. Waldram, speaking as an engineer, referred to the tremendous strides which reinforced concrete had made during the war. There was one thing, however, which would stop it entirely, and that was the present building legislation. On the question of standardisation, he thought it was desirable to standardise doors, windows, etc., but he was against standardising in outside design and plan.

Mr. Edward Warren said he saw no objection to the use of concrete blocks in cottage construction ; the chief point was not the difficulty of the walls, but the difficulty of the roof. What were they going to use for roofing in districts that did not produce tiles ? Where they could get red tiles concrete cottages would look very nice, but if they were condemned to use the common blue Welsh slate nothing on earth was going to beautify such work. As to standardisation, they should have a considerable number of sizes adaptable to various conditions, and by adroit planning it was perfectly possible to get a very fairly pleasing effect from standardised buildings.

Mr. H. R. Aldridge (Housing and Town Planning Council) dissented to the suggestion that cottages should be standardised, and said he did not believe the working classes would stand such treatment. He was also inclined to think that Dr. Faber was much too optimistic in the economy that standardisation would effect. With regard to the building bye-laws, the Tudor Walters report suggested a way out of the difficulty—that in housing schemes submitted to the Government there should be *ad hoc* building regulations and bye-laws for any particular scheme. He felt convinced that neither the working people of the country nor the local authorities would have standardised cottages.

A vote of thanks to the speakers and to the Chairman for presiding terminated the meeting.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Coast Erosion and Protection. By Prof. E. R. Matthews, Assoc.M.Inst.C.E., F.R.S. (Ed.), etc. Second Edition Enlarged.

Published by Charles Griffin & Co., Ltd., London. Price 12/6 net.

The fact that engineering, though a science, is by no means an exact science is part of its charm. The engineer has to pay the greatest attention to the physical laws of nature, but when he comes to apply them, he finds them so complex and often so conflicting that he frequently has to discard his calculations and fall back on the inspiration of his experience, observation and common sense. This is especially the case in the design of works of protection from the sea, and is well exemplified in Professor Matthews's work on coast erosion.

The author writes with a full knowledge of his subject, as he has studied the action of waves and currents, and moreover has himself designed many admirable works of coast protection. His book therefore contains much original matter and will be read with pleasure by all students of the subject. Its most striking features are the descriptions of the author's experiments on models of foreshores, which remind one of Professor Osborne Reynolds's famous experiments on estuary models, and the excellent photographs of waves with which the book is illustrated.

In the first chapter Professor Matthews deals with the laws and effects of waves, and draws attention to the curious fact that the greatest destruction to protection works is wrought by off-shore gales. The photographs illustrating this part of the subject are most illuminating. The next two chapters deal with erosion and accretion on the East and South Coasts of England, and a full account is given of the vanishing coast in Yorkshire north of the Humber. The author blames the Royal Commission on Coast Erosion for not recommending the Government to give grants in aid to those local authorities or landowners who spend, or ought to spend, large sums in protecting their foreshores, and points out that in France and other foreign countries coast protection is a national duty. In the absence of such grants many acres are being washed away every year, and this is, of course, a strong argument in their favour.

The next four chapters describe sea-walls of all shapes and materials. The chapter on reinforced concrete sea defences is of special interest.

The eighth chapter describes some experiments carried out by the author to find the effect of sea water on concrete. Unfortunately, but few of the specimens tested were more than 28 days old, and, moreover, those subjected to the action of sea water were simply immersed in it. In cases where sea water has destroyed concrete it has generally been where sea water has been forced through a porous material under pressure. The comparatively gentle treatment of these briquettes is hardly comparable with such cases.

Chapters IX. and X., on groynes, bring out clearly the advantages of low groynes over the old-fashioned high type. Chapter XI. contains matter which is interesting, but which might with advantage be incorporated in the preceding chapters. Chapter XII. gives a short description of the various materials used in sea protection works. Professor Matthews here remarks that mass concrete walls require more repairs than any other type. Probably this is so, but is largely due to the poor quality of concrete which is sometimes used in mass concrete structures. If the materials and workmanship usually found in good reinforced concrete are used for plain concrete its strength and durability will equal that of all but the very hardest stones.

The last two chapters are perhaps the most interesting of all. In the former the author deals with the damage that is often done to foreshores by projecting breakwaters which arrest the travel of shingle, and thus not only denude the leeward coast, but also cause silting within the harbour itself. Professor Matthews maintains, no doubt rightly, that this evil can be partly overcome by aligning the breakwater in such a way as to lead the shingle along the coast instead of arresting it. Moreover, he has strengthened his opinion by the aid of the most ingenious models of the harbours under consideration. His model consists of a tray which represents the foreshore, and which is covered with real sand and flowing water, the breakwater and adjoining cliffs being formed with plasticene. With such models he has been able to show the combined effect of the tidal currents and of the obstructing breakwater on the movements of the sand, and the results seem to be highly instructive. In the last chapter he describes the effect of waves on various types of breakwater, and again he has shown how these effects can be reproduced on models. They illustrate, for instance, the fact that a curved batter on a wall assists the waves in leaping over it, and that this type of breakwater is not to be recommended.

The photographs and drawings are well reproduced and add much to the value of the book.

From War to Work. By Samuel Turner.

London : Nisbet & Co., Ltd., 22 Berners St. 109 pp. + xiii. Price 1s. 6d. net.

Contents. — Foreword — Introduction — The Conscious Aim—The Disordered Life — The Peace Offensive — In Theory—In Practice—The Philosophy of the Steam Shovel—Can We Afford It ?—Our Restriction of Output—Can We Produce Too Fast ?—Some Facts about Consumption—Profits in Theory—Democratic Profits—The Social Value of Profits—The First Move—Conclusion.

As will be seen by the contents above, this book is not in any sense a technical one dealing with constructional problems, but it is of such general interest that it is well worthy of notice. The author deals very clearly with matters of national importance, and his ideas and facts are so well expressed that it would be an excellent thing if a copy of the book could be placed into the hands of every member of the British Empire. This war has entailed undreamt-of hardships and sacrifices, and it will need a great deal to compensate for all the suffering, and if our lesson is thoroughly learnt, our wonderful efforts during the war will not be allowed to die down, but they will be merely transferred to other channels, wherein the results will be for the benefit of the community and progress in industry, science, and art will proceed apace. It is impossible to deal at length with any of the matters put forward by the author in a short notice of this nature, but particular attention may be drawn to the chapter dealing with our restriction of output, which entails such a big loss to the nation, and to the comparisons between the production per man in this country and the United States of America. The facts and figures which are given in these two chapters alone should be sufficient to rouse the reader to a sense of his responsibility to do his bit in the interests of progression after the war.

A Primer of Engineering Science. By Ewart S. Andrews, B.Sc.

London : James Selwyn & Co., 10 Essex Street, Strand, W C.2. 67 pp. + ix. Price 3/9 net.

Contents. — Forces and Other Vector Quantities — Moments and Leverage—Work, Power and Energy—Machines and Efficiency — Mechanisms — Belt, Chain, and Toothed Gearing — Friction and Lubrication — Stress and Strain — Types of Heat Engines — The Measurement of Heat Energy — Specific Heat and Latent Heat — Properties of Steam — Expansion of Gases, Liquids and Solids—Indicator Diagrams — The Transmission of Heat Energy — Answers to Exercises.

This volume is divided into two parts, and it is intended as an introductory text-book for engineering apprentices and students in technical institutes and schools, and it differs from other volumes in that it contains matter dealing with both the elements of mechanics and the theory of heat engines. The contents are based upon a syllabus outlined in a memorandum issued some time ago by the Board of Education, and it is a step in the right direction, as it removes a barrier which has been placed in the past between the different subjects that come within the studies of the engineering student. The different matters are dealt with very clearly throughout and the text is expressed in a simple manner, which will commend the book to the student, while numerous explanatory diagrams are introduced. A very useful feature is the introduction of a summary at the end of each chapter and the exercises, together with the answers, will enable the reader to test his progress even when studying without the aid of an instructor.

Tidal Lands—A Study of Shore Problems. By Alfred E. Carey, M.Inst.C.E., and F. W. Oliver, F.R.S.

London: Blackie & Son, Ltd., 50 Old Bailey, E.C. 284 pp. + xiv. Price 12/6 net.

Contents. — Tidal and Current Data — The Tidal Compartment of a River — The Foreshore — The Function of Vegetation — Sand Dunes — The Fixation and Plant Protection of Sand Dunes — Shingle Beaches and their Fixation—Tidal Land Reclamation — Erosion and Accretion — Plant Winning of Tidal Lands — Salt Marshes — Miscellanea — Blakeney Point, Norfolk, from an Engineering Point of View—The State and Local Control—Complementary Problems—Appendices.

The subject of coast protection and maintenance is a very important one, and the problems met with by engineers engaged in such work are varied, and call for considerable skill if success is to attend their efforts. This volume will be welcomed as a very complete treatise, which embodies the experience and observations of the authors over a period of many years, and the book is so well written that the subject becomes quite fascinating to anyone who is interested in the working of nature, apart from any question of engineering. The authors treat with the maintenance of tidal channels, land reclamation, and the preservation of foreshores, and a very important part of the text throughout is devoted to the consideration of horticulture as a means of conservation.

The various chapters are illustrated by numerous diagrams and photographs, which are helpful and interesting, and the question of State and local control is thoroughly dealt with.

Several examples of both plain mass concrete and reinforced concrete are given, and in connection with these the authors deal with the necessity of concrete structures being absolutely watertight to prevent disintegration in sea water.

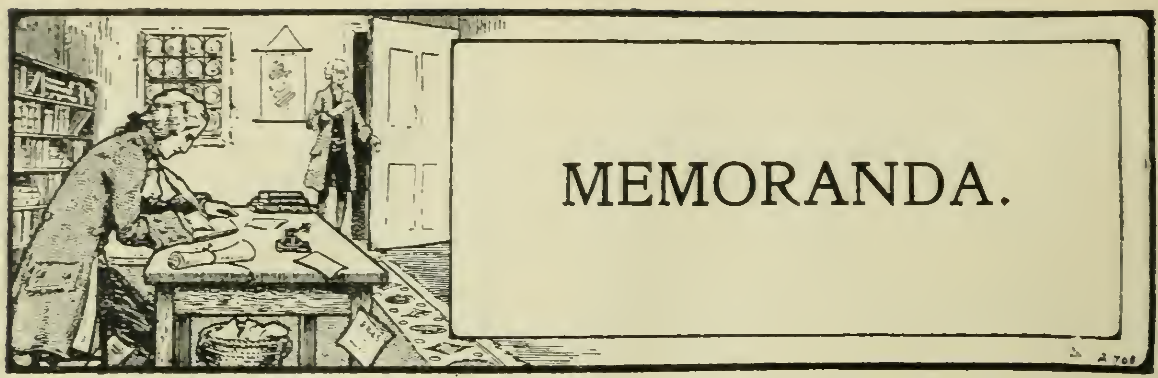
The volume can be thoroughly recommended as one which is very practical, and it will prove useful both as a text book and a book of reference.

Reinforced Concrete Theory and Practice, by Frederick Rings, U.S.A.

London: B. I. Batsford, Ltd., 94 High Holborn. 260 pp. + xi. Price, 10s. 6d. net.

Contents. — Introductory — Materials — Execution of Work—Applications of Reinforced Concrete—Loads, Moments, Stresses, Resistance—Formulæ for Slabs with Single Reinforcements—Shearing Stresses and Adhesion—Formulæ for Columns—Arch and Bridge Construction—Retaining Walls, Circular Structures, etc.—Worked Examples—London County Council Regulations—Memoanda and Tables—Symbols—Ready Reckoners.

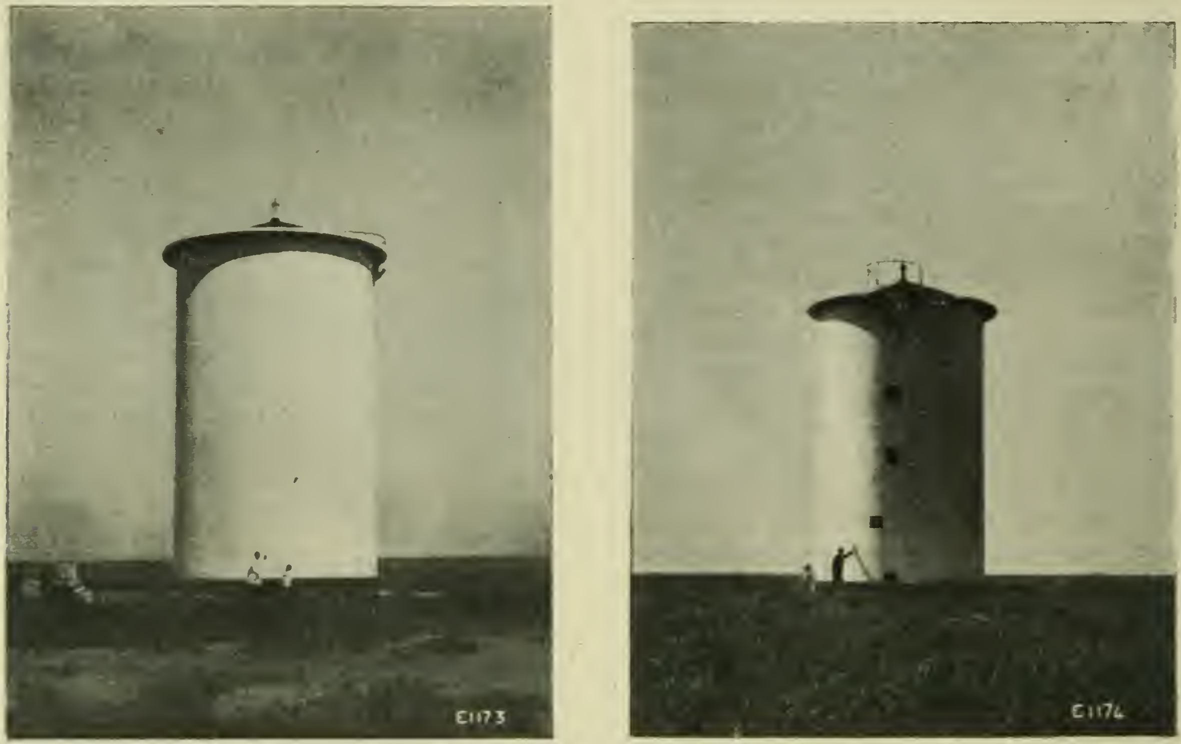
This is a revised and enlarged edition of the author's book which was first published in 1910, and it is stated in the preface that the formulæ and calculations have been brought into conformity with the regulations of the London County Council, which are included in the text. There is a marked improvement in the present volume as compared with the previous edition, as many of the errors which occurred in the latter have been eliminated, but the arrangement of the ready reckoners for slabs and beams and Tee beams is very unsatisfactory, as they are attached to the covers in such a manner that their accurate use is almost impossible. The chapter on Retaining Walls, Circular Structures, Domes, etc., is an important addition, and we are glad to see that the worked examples have been entirely revised and extended. It would have been preferable, however, if these latter had been attached to the theory dealing with each particular type, as they would then be taken by the student in conjunction with such theory, and full advantage could be taken of the examples to make them read in sequence with the other text. Many of the diagrams are satisfactory, but many also are so small that they are very indistinct. The theoretical portion of the subject generally has, in our opinion, not been dealt with as thoroughly as it should be, as there appears to be a tendency to pass over some very important matters. As an example, there is no attempt to give the reader any assistance in the calculation of column links when increased stress in the concrete due to more than the minimum hooping is permissible, either in the theory or in the examples, and this principle applies throughout. In any future edition it is to be hoped that the author will endeavour to extend the usefulness of the book by the inclusion of all the essential points in connection with the theory and its application to practical design.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Reinforced Concrete Silos for Green Forage.—The accompanying illustrations show some cylindrical silos erected in the Argentine Republic by Messrs. Guitarte & Sanchez of Buenos Aires, for the storage of green maize. Silos of varying capacity have been erected . Generally speaking, they are 38 ft. high, and of 18 ft. diameter. The thickness of the walls, base, and cover is 3½ in., and the concrete is a 1 : 2 : 4 mix of cement, sand and broken granite. The walls and roof are plastered on the interior and external surface with cement. As will be seen from one of the illustrations there are five doors to the silos at varying levels, the outer covering of these doors being of iron and the inner of wood. Messrs. Guitarte & Sanchez inform us that the time occupied in the construction of these silos was 40 days.



REINFORCED CEMENT SILOS IN SOUTH AMERICA.

New Fishmarket at Grimsby.—We learn that the Great Central Railway have decided to proceed with the rebuilding of the Grimsby Fish Market at a cost of £140,000. The work will be carried out in reinforced concrete with steel lacings, and will give accommodation to meet the growing requirements of the trade.

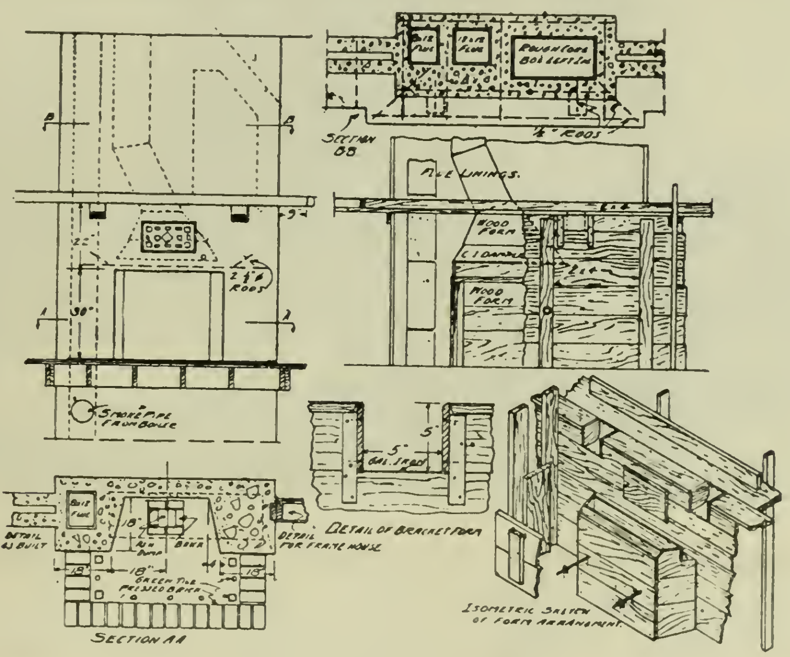
Concrete Cottages.—The Associated Portland Cement Manufacturers has offered to provide sites for erection of ten cottages in the parish of Burham and twelve in Aylesford at a peppercorn rent.

Concrete Fireplace Forms.—In a recent issue of *Concrete, U.S.A.*, are some illustrations of details of forms for a concrete fireplace, which we reproduce below. We also give an illustration of the fireplace as finished. It was built in a house having concrete walls and floors, but details are shown adapting its use to frame construction. The design is plain and the form simple. Two pairs of vertical planks determine the thickness and relation of the house walls. Against these verticals are built the mantel forms of dressed lumber. The small bracket forms are of wood and sheet metal set in notches in the main forms, which are undercut, as shown, for clearance in stripping. The bracket forms are secured by strips accessible from the outside.

The form for the fireplace is drawn in at its top to conform to the cast-iron damper, and provides for the face of the fireplace to drop below the level of the damper. The whole is well reinforced, as shown.

The concrete face consisted of a washed sand and gravel, having all the pebbles between ¼ in. and ⅜ in., that could be put into the mix without voids. Concrete was placed from the outside in a semi-dry mix. The back form, a plank panel, was raised as concreting progressed.

Forms were stripped in 24 hours, and the face of the work scrubbed under a stream of water to expose the aggregate. The mantel-shelf was faced with sand mortar, and when hard, rubbed smooth with a carborundum brick.



Forms for Concrete Fireplace.

The ornaments on the panel and hearth are green hand-made tile, and the row of red bricks that borders the hearth is raised about 1 in. to retain ashes. A row of bricks surrounds the ash dump.

The concrete above the mantel was left rough and plastered with the rest of the room, while the outside received a coat of mortar and was dashed with the exterior of the house.

The Increasing Use of Concrete in the United States.—Mr. Harvey Whipple, the Editor of our contemporary, *Concrete, U.S.A.*, has recently issued a report showing the increasing use to which concrete was put in the United States during the last two years. We give this report below in abbreviated form :

The British Steel Piling Co.

ZENITH CONCRETE MIXERS

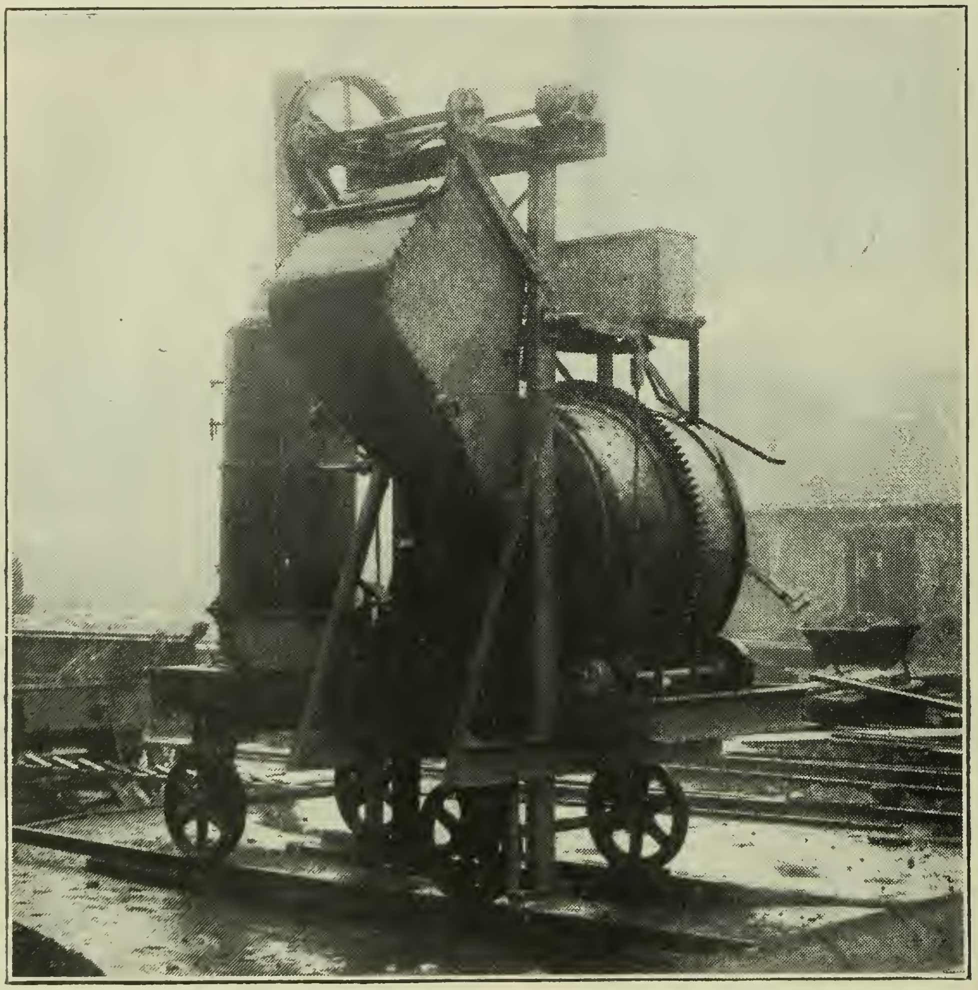


Illustration shows a three-quarter yard "Zenith" Mixer with automatic side loader and driven by steam engine. The workmanship and materials are of our usual high quality.

Remember the word "Zenith" on your Equipment is the Hall Mark of quality.

ON SALE OR HIRE

Dock House, Billiter Street, London, E.C.

Roads.—Concrete has supplied a real solution of pressing highway problems, having proved to be the only surfacing material that can be expected to stand up under the wear of heavy motor traffic.

Ships.—The concrete ship is another outstanding war development in the concrete field. The programme of the United States Shipping Board calls for forty odd vessels of reinforced concrete, and there are other concrete ships building for other Government departments.

The advent of the stone ship has brought with it other advances, including a more serious consideration of the subject of fine grinding of Portland cement.

The concrete ship also necessitated serious thought as to the weight of the material which has resulted in the development of light-weight aggregates made chiefly from burned clay, which, while insuring extreme buoyancy, are giving very high strength on early time tests of the resulting concrete.

Then, too, the development of the ship has laid upon its builders the necessity for closer study of the problems of mixing, of placing, and of consistency that there may be obtained concrete of the very highest quality, in thin sections and wherever it must surround a complicated network of steel reinforcing members. Concrete for ships must be without stone pockets or bad spots ; it must be thoroughly homogeneous in mix ; it must be placed with the utmost care.

This need, in turn, has led to experiments with the " cement gun " as a means of placing a concrete without the use of forms.

Storage Tanks.—The concrete storage tank is second only to the concrete ship as a product of war conditions. The concrete oil storage tank is assuming a position of vast importance. It cannot be considered merely a temporary war development, because, at least for the heavier oils, concrete has demonstrated its worth beyond question. Painstaking contractors have built such successful underground tanks for the storage of heavy oils that no coatings have been necessary to prevent the escape of the valuable contents, either by leakage through cracks and pockets, or by seepage through a pervious wall. Even for the storage of light volatile oils the concrete tank is being seriously investigated, not only by the United States Bureau of Standards and by the Portland Cement Association, but also by the Standard Oil Company. With such oils it is believed that it will be necessary to coat the concrete with some material to prevent loss by seepage and evaporation.

For other liquids also the concrete tank is coming into extensive use. In some plants concrete tanks are holding acid solutions. For such uses it is obviously necessary that the concrete be of the highest quality and coated with an acid-proof material.

The Farm.—Of a kindred nature is the development of concrete silos for the storage of green fodder, thousands of which have been built in the last few years. Indeed, the farmer is becoming one of the biggest users of cement. He is adopting concrete for his small buildings to escape repair bills and fire danger ; and he is constructing concrete feeding floors, dairy buildings, storage pits, and storage sheds.

Structural Members.—Very early in the war the structural steel shortage turned the attention of engineers to the designing of a greater variety of concrete structural members than was then known.

Concrete Blocks.—The concrete block, as a unit for building construction, was not for a long time held in high regard by the best architects. But now block manufacturing is being carried on by skilled men who are devoting themselves to the serious problem of producing material of some esthetic value, so that the concrete block for house construction has more than held its own.

Reinforced Concrete Railway Wagons.—We learn that a factory has been established for making railway wagons of reinforced concrete at Doetinchem. Experiments in this direction are also being carried out in Norway. Our readers will recollect that we briefly referred to similar activities in this country and U.S.A. some time ago.

CORRESPONDENCE.

Tables of Loads on Steel Pillars.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—It is not the usual practice for an author to reply to criticism of his book in review, but I would like to have the opportunity of removing an erroneous impression which is left by the review in your November issue of the book of tables by Mr. Cocking and myself.

Your review states that : " These tables are very useful, and they will be more so when the authors are in a position to publish corresponding tables for other sections, as they state it is their intention to do when the opportunity occurs. It will be clear that the designer so often requires to continue the same section of beam through several floors, with the addition of extra flange plates as required to take the additional load, that full value cannot be obtained from this book until the other tables are available to enable him to design a pillar in this way for the full height required."

I just want to point out that these tables are intended to fulfil this very purpose ; they give the strength for the same section with flange plates varying in breadth and thickness so that a pillar can be designed for the full height required. If we knew of any other tables which did this to anything approaching the same extent we should not, of course, have undertaken the labour of calculating fresh ones.

Yours truly,

EWART S. ANDREWS.

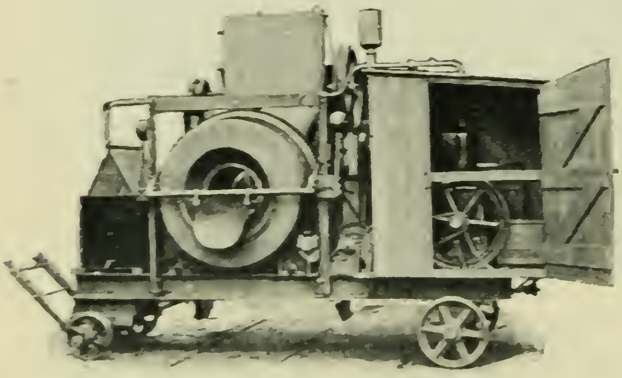
London, *January*, 1919.

PUBLICATIONS RECEIVED.

Reports.—Annual Report of Railway Bureau of Government-General of Chosen for year ending March 31st, 1917.

An Octaval Coinage.—A pamphlet by Alfred Watkins, on Octaval Coinage *versus* a Decimal Coinage (price, 3d., obtainable from any bookseller).

Concrete Floor Slab Reinforcement.—In a previous issue we referred to the pamphlet which had been published on this subject by the British Reinforced Concrete Engineering Co., of 1 Dickinson Street, Manchester. Readers will be interested to learn that a mounted wall card has now been prepared by the above firm for the use of engineers and architects. The card should be of great use to those for whom it is intended.



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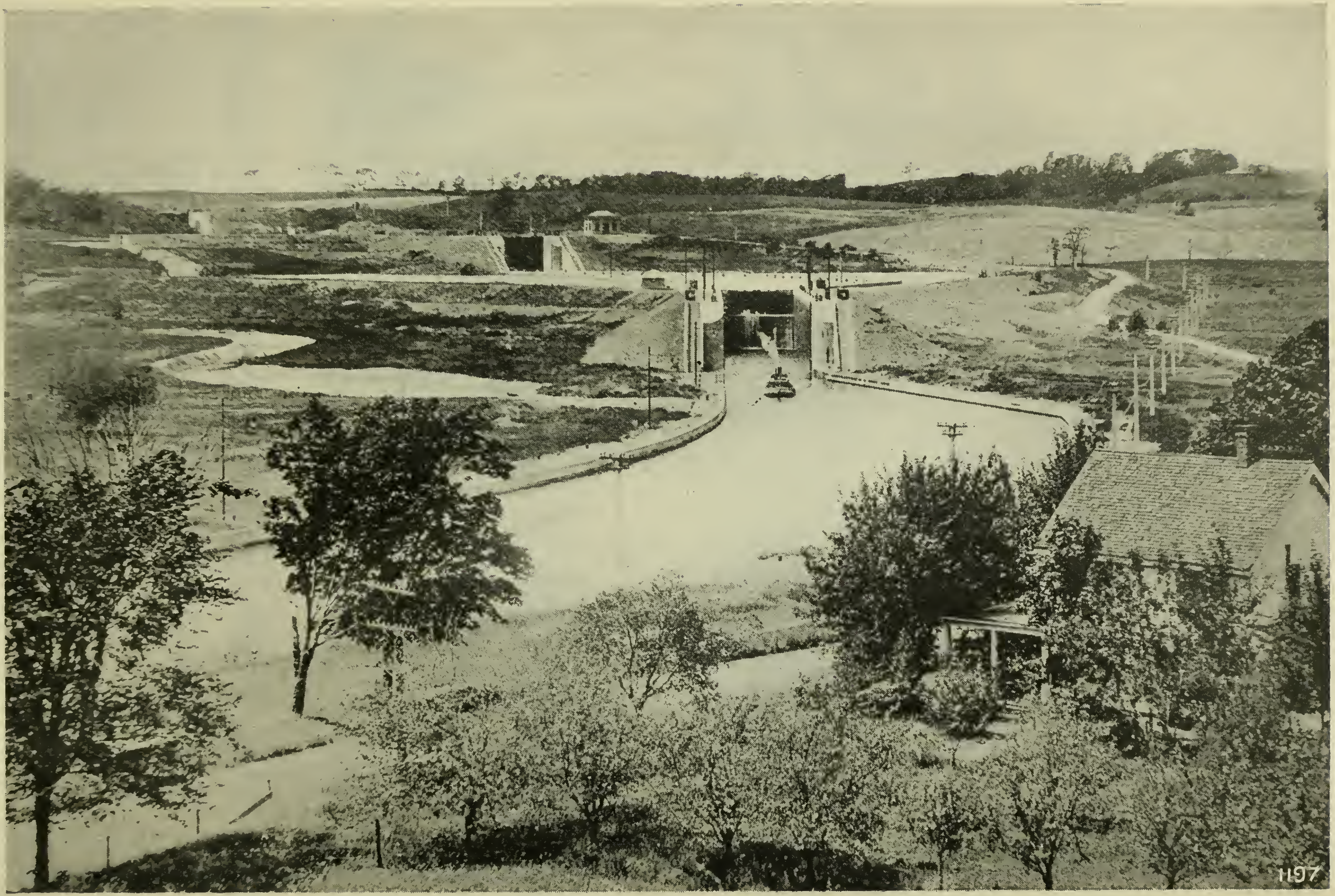


View showing three of the Massive Locks on the New York State Barge Canal
(*For description see page* 121.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 3. LONDON, MARCH, 1919.

EDITORIAL NOTES.

RECOMMENDATIONS FOR REINFORCED CONCRETE WORKS.

INTRODUCTION.

A PAMPHLET has been issued by the Concrete Institute which contains recommendations to inspectors, clerks of works and foremen concerning the execution of reinforced concrete works, and it is interesting as indicating the progressive nature of the Institute's programme and the real desire to assist those responsible for the supervision and carrying out of concrete work to ensure an intelligent application of the material. It is a well-known fact that the best work is always produced by persons who are interested in their labour, and in order to stimulate and keep this interest alive it is necessary that the worker should understand the essential principles that govern the design and appreciate the reasons for certain operations. In the introduction it is stated that the supervisor should have a clear idea of the general principles of reinforced concrete construction in order that he may understand the purpose for which reinforcement is provided in the various members of the structure, and he should read carefully the specification to ensure that all requirements may be fulfilled.

This is certainly true, and we should go even further than this and state that a supervisor is absolutely incompetent unless he has a thorough knowledge of all the principles which govern the design in order that he may appreciate the importance of faithfully adhering to the designer's instructions and details throughout. We have found on many occasions that a few simple explanations to foremen and workmen as to the function of various portions of the reinforcement in suitable language has had the effect of causing them to look upon the accurate placing and other matters as points of such importance that a certain keenness, born of understanding, has developed which has facilitated the execution of the work in a first class manner, and the designer is well repaid for his apparent condescension and trouble. In one instance it was found that the shear members provided in the column bases in a large scheme were being omitted in spite of a special warning being given to the foreman, as he apparently looked upon them as superfluous. As a result of this the foreman was quietly taken aside and given an elementary lesson on the principles governing the design of column bases and the importance of these rods was made clear to him. He became very interested; and took extraordinary precautions in the subsequent work to see that the omission did not occur again, and he asked for information in connection with other portions of the work, with the result that he began really to understand the properties of the material he was executing, and confessed that he felt a sense of responsibility and his work assumed quite a different aspect.

The average foreman is quite willing to learn and be influenced in this way, and any attempt to assist him, whether it be individual or collective, is to be welcomed.

There are many good points in the pamphlet that has been issued, but without being accused of unnecessary criticism, we feel that we can say that it does not cover the ground sufficiently, and the omissions are, in many cases, serious ones which will have the effect of detracting from the value of the pamphlet to those for whom it is intended.

It will be impossible to deal with the whole of the points which should be included in the recommendations to make them complete, but a few may be mentioned here as a justification for our criticism, and also with the view of bringing them to the notice of those responsible for the pamphlet for future consideration.

DEFINITION OF TECHNICAL EXPRESSIONS.

Only three expressions are given under this heading—viz., neutral axis, lever arm, and double reinforcement ; but there are several others with which the supervisor should be familiar, and of which he very often has no real understanding, and it would be advisable to extend this list to cover all the important general terms, because it must be assumed in a pamphlet of this kind that the reader knows practically nothing of theory, or, at most, very little. Without attempting to include numerous terms which may be helpful, we suggest that simple explanations should be given of reactions, bending moment, moment of resistance, point of contra-flexure and eccentric and axial loads. It would possibly be surprising to many if these terms were put before the average clerk of works to see how vague is the understanding with regard to such apparently simple expressions.

FORM WORK.

The notes under this heading are more complete, and yet the knowledge generally on this portion of the subject will be found amongst foremen and clerks of works to be good, because they are familiar with the use of timber, and there is no sense of uncertainty about its application and behaviour under given conditions. This section, therefore, can be considered as satisfactory, and as covering all the essential points.

REINFORCEMENT.

Some very good notes are given under this heading, but they are very general in character, and appear to lack specific information on the points which usually cause the most trouble to the man of limited experience in reinforced concrete work. For example, no mention is made of the best method of bending large rods to ensure accuracy, and some useful hints could be given on this. The effect of heating the bars to nearly a white heat, as is sometimes done for the purpose of bending, should be explained, and also the use of small template bends. The reason for hooking the ends of tension rods, and the method of treating compression rods should be included, and, although it is mentioned that the reinforcement must be kept fixed in position during concreting, there is an absence of advice on typical and efficient methods of ensuring this. The difficulty of keeping cranked rods upright during the concreting of floor slabs is a very real one to many foremen, and it would have been helpful if reasons had been given as to the strict necessity of this being faithfully carried out with some small sketches and descriptions of the use of small notched boards for the purpose, and how such boards will ensure accurate spacing, etc. The use of models or building up of the reinforcement for a typical member are not mentioned, and yet these methods are very useful for complicated work. We have seen column bases in which so much steel occurs that it has been practically impossible for the foreman to realise the correct arrangement of the rods and stirrups without first making a small model for the guidance of himself and his workmen, and, in some cases, these models have had the effect of showing the purely theoretical man that the design as prepared is physically impossible of execution. The function of shear members in column bases should be explained, and the importance of putting these in where shown should be emphasised. Methods of spacing the links in columns might with advantage be mentioned, and the question of keeping these in position during concreting should be dealt with. When on the question of reinforcement some mention of the need of sufficient lap where the junction of rods takes place without the use of sleeve pieces, and how the lap must be properly made to be effective in conducting the stress from one rod to another should have been mentioned. No explanation is given of the reason for the introduction of distribution rods, and yet many foremen look upon these as quite superfluous, because they have had no explanation of the function of such rods. There are many similar instances of the omission of notes in this section which would have proved very helpful to the practical man in furnishing him with greater intelligence on that part of the subject which is of primary importance—viz., the proper preparation and application of the steel.

MIXING AND PLACING OF CONCRETE.

The recommendations under this heading are fairly comprehensive, and should be of assistance, but there are some points which we should wish to see included for the guidance of those for whom the pamphlet is intended. As an example, no mention whatever is made of the importance of proper tamping during the placing of the concrete, and how this can be executed in the most effective manner, also how the tamping should be done to acquire a good surface. This is a serious omission, as the quality of the work can be much impaired by lack of attention in this respect.

The depositing and method of breaking off in the process of concreting generally seem to have been overlooked, and the reason for this is difficult to understand. The amount of water to be used is mentioned in general terms, but this item could, with advantage, have been amplified, and it would have been instructive if the effect of too much or too little water on the strength of the mixture could have been explained, as this is a matter on which a great deal of ignorance prevails among inspectors, clerks of works and foremen. It frequently happens during the execution of the work that runs across newly placed concrete are required, but no warning is given on this point, and no guidance is offered as to the sequence of the work in relation to the location of the mixing plant.

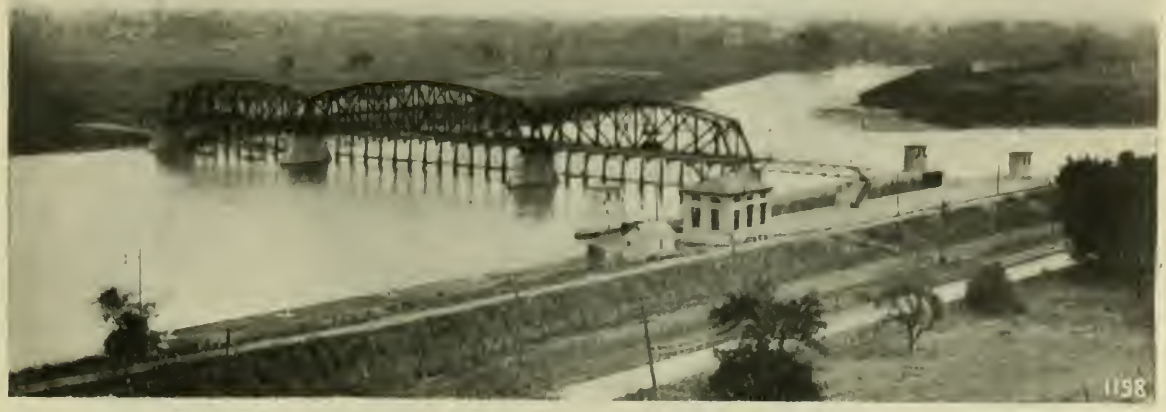
TESTING.

The notes under this heading are brief, and cover those points with which the average inspector will be familiar. It would have been preferable if some particulars had been given as to the size of the test pieces which should be prepared and the different requirements for concrete specimens for compression and shear tests. No mention is made of the necessity for making wooden moulds so that they can be dismantled without damage to the concrete, and many items similar to this might be mentioned.

GENERALLY.

We feel that the pamphlet is only a small step in the direction where a big stride might have been taken, and it lacks a completeness which is so desirable in a publication offered to the man on the works as a guide to all the essential points of a form of scientific construction with which he may not be quite familiar.

There are no notes on tee beams, which occur in practically all schemes, and the question of pre-cast units is entirely ignored. It would have been a good plan if the committee responsible for the drafting of the recommendations had taken the standard specification of the Institute and explained the reason for all the items which may not be apparent to the practical man, and at the same time some evidence as to the requirements of the average clerk of works and foreman could have been gained by a friendly consultation with a few practical men. To the notes obtained by such methods should be added some simple explanations of the essential principles governing the design of the material, with a clear definition of the general technical expressions ; and the pamphlet should be so comprehensive that it would prove a real guide and friend to all the responsible men in charge of the execution of the work, and become a link between the textbook of the student and the actual structure.



View of Movable Dam and Lock as seen from the Upper Level.

THE NEW YORK BARGE CANAL.

Linking the Great Lakes with the Atlantic Ocean.

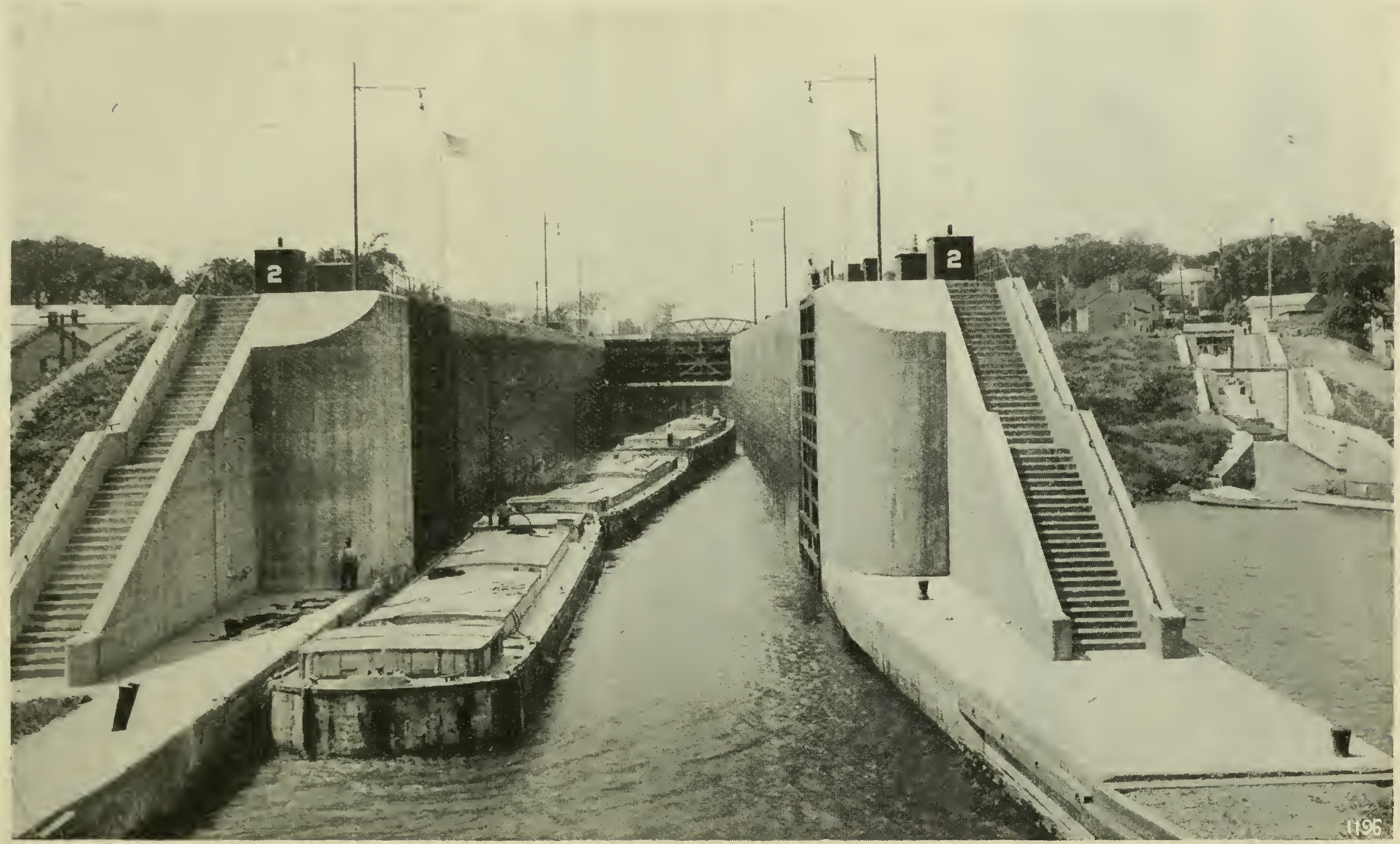
By
ROBERT H. MOULTON,
Board of Trade, Chicago.

The following are some additional interesting particulars of the New York State Barge Canal, on which we published a short article in our issue of October, 1915. Of special interest are the Locks constructed of concrete to which special reference is made in this article.—ED.

An event of national importance was the formal opening, recently, for through traffic of the Barge Canal of New York, remarkable both for its picturesqueness and for the engineering difficulties overcome in its construction, which links the Great Lakes with the Atlantic Ocean. The completion of this great inland waterway, which required thirteen years to build and involved the expenditure of approximately $150,000,000, will be a wonderful boon to transportation. It will relieve the railroads of a tremendous quantity, of course, of non-perishable freight. Its capacity is estimated at 10,000,000 tons annually, which is the equivalent of 500,000 car loads.

The canal is made up of four different channels, all of which have the same general dimensions, the depth being about 12 ft., and the width varying from 75 ft. in earth sections of the " land line " to a minimum of 200 ft. in the beds of canalised rivers and lakes. These channels are: the Erie Canal, or main line, between Buffalo and Troy; the Oswego, running from Syracuse to Lake Ontario; the Champlain, extending from Troy up the Hudson to Lake Champlain, and Cayuga-Seneca, connecting the so-called " Finger-Lakes " with the main channel. By means of the Hudson River, New York City and the municipalities and villages south of Albany are brought into touch with the system.

This new channel was constructed in accordance with principles radically different from those which governed on the old canals. On these old channels the idea was to keep the hillside above the rivers and streams and to use animal power for towing purposes. In the present work, however, the practice in vogue on the Continent, where the low-water routes in which the natural streams are used, has been followed wherever practicable. In fact, the larger part of the new system consists of the canalisation of the rivers and lakes.



A Tow of Canal Boats leaving the Chamber of Locks 2 of the Waterford Series.
(Note Old Canal Locks on the right).
THE NEW YORK STATE BARGE CANAL.

In order to make navigation possible on the rivers and lakes, it was necessary to maintain a specified minimum depth and provide what is termed " slackwater navigation." This was accomplished by the construction of dams and locks, the dams holding the water at a more or less fixed elevation above the level of the stream, and the locks permitting the barges to move from one level to another. Between Little Falls and Troy, on the Erie Canal, ten dams have been constructed, which provide for navigation on the canalised Mohawk River. Two of these structures are of the " fixed type," while eight are movable. These actually make the river a series of lakes, the water between the dams being practically level and ordinarily without much current. A lock is constructed at one side of each dam to enable the barges to pass from the different levels.

Many travellers across the State have wondered at the movable dams which appear to be steel bridges, yet have no approaches. This type of structure was necessary, however, because from the bridge floor of each structure the controlling works, which swing underneath, are operated. These works consist of heavy steel frames and gates which may be lowered or raised at will by operating electric winches running on the bridge floor of the dam. The particular function of the movable dam is that when the gates are raised, during the winter months and spring flood period, it allows the river to flow on uninterrupted, while during the navigation season it serves its full purpose as a dam and may be so operated as to pass a large or small quantity of water, thus keeping each pool at its proper level.

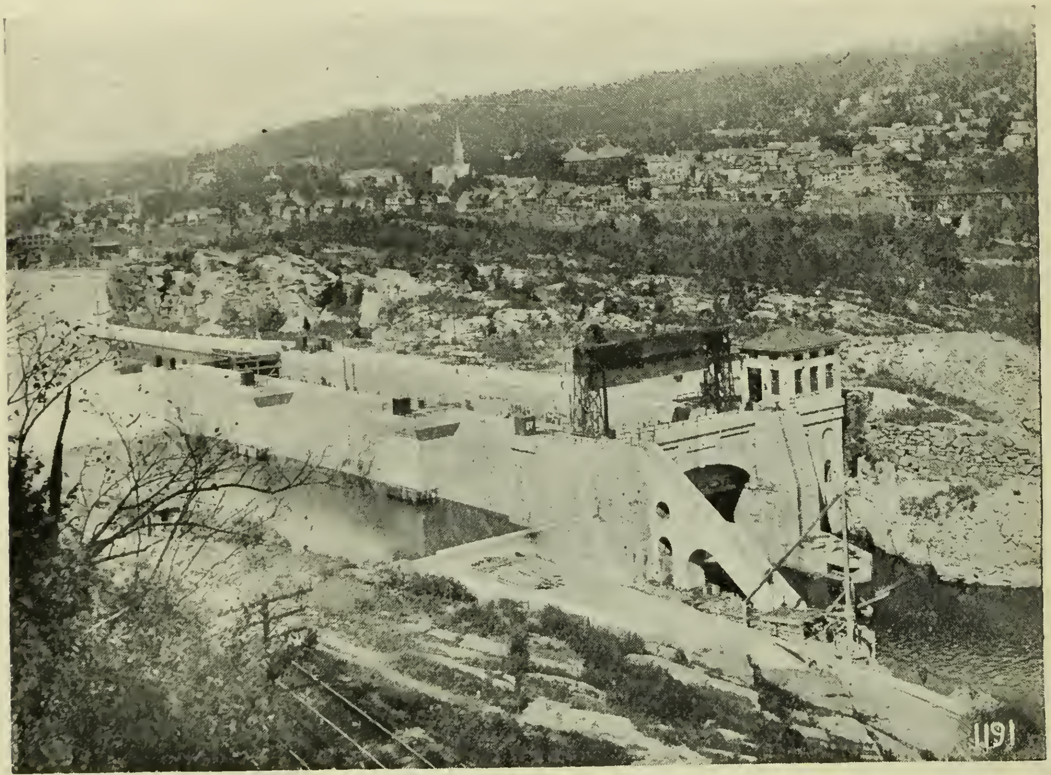
There are thirty-six locks on the Erie Canal, all of which are massive concrete structures, having inside rectangular dimensions of 300 by 44·44 ft. and a lifting capacity varying from a few feet up to 40½ ft. At Waterford the locks are so constructed that a series of five serves to lift the barges from the Hudson River to the canalised Mohawk River, 169 feet above the level of the Government lock at the Troy Dam. These structures have been called the world's greatest series of highlift locks, and their lift is double that of the locks in the Panama Canal from sea level to summit.

One of the highest lift locks in the world is located at Little Falls, where the difference in pool elevation is 40½ ft. This massive structure has concrete side walls, which stand 80 ft. high, and are 30 ft. wide at the base. The lower gate is of the lift type, and is raised and lowered, instead of being swung open and shut as are the gates on other locks.

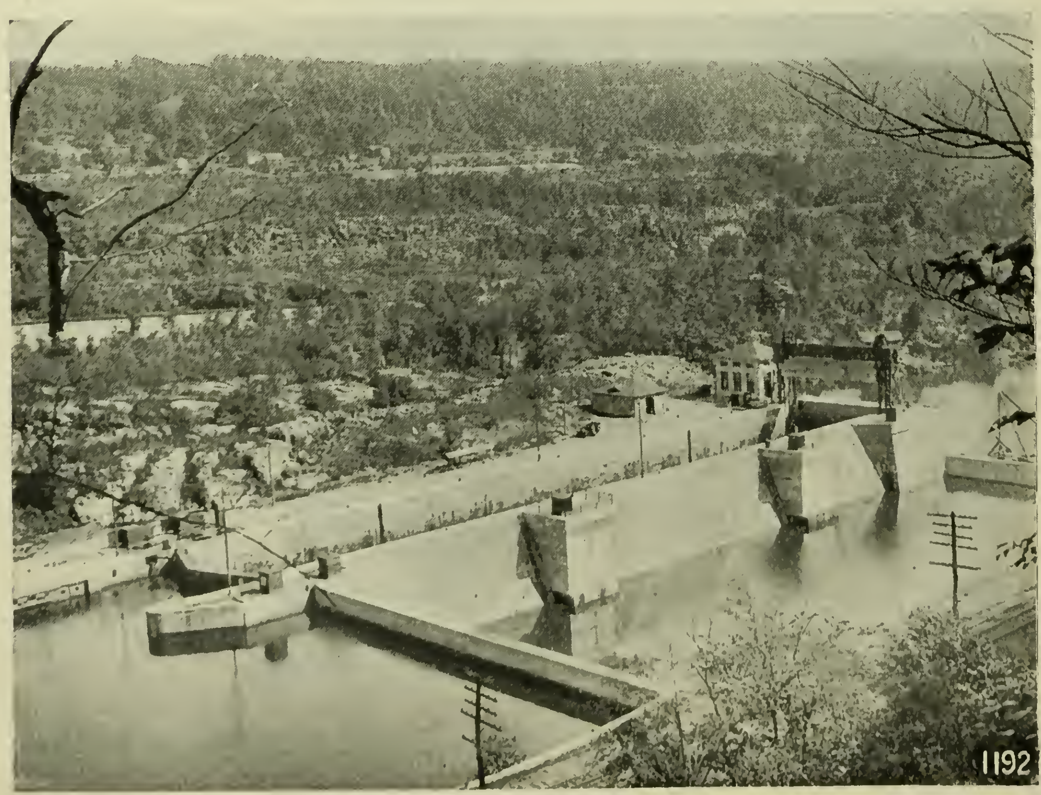
In the operation of all locks the water is admitted to and drawn from the chamber by means of culverts running through the side walls, and the openings have been so designed that the filling and emptying of the chamber is only a matter of a few minutes. The locks are all electrically operated and the chambers are filled or emptied while the gates and valves are opened or closed by simply turning a lever. Safety devices are also arranged so that errors in operation or navigation are practically eliminated.

The Erie Canal is spanned by 232 bridges, of which fifty are railroad crossings. The clearance under these structures must be at least 15½ ft.

In the " land line," guard gates have been provided which are located about ten miles apart. These are steel structures, suspended from towers, and may be lowered to hold the water, in case of emergency, such as might exist if an embankment became weakened or any similar accident made it desirable to unwater any section of the channel. Numerous culverts and spillways, which keep the water from overflowing the banks, have been provided, and 100,000,000 yds. of earth and rock have been removed, while 3,000,000 yds. of concrete have been placed. While the actual construction period has been about thirteen years, this,



Little Falls Lock, Lift 40½ feet.



Little Falls Lock as seen from the Upper Gate.
The New York State Barge Canal.

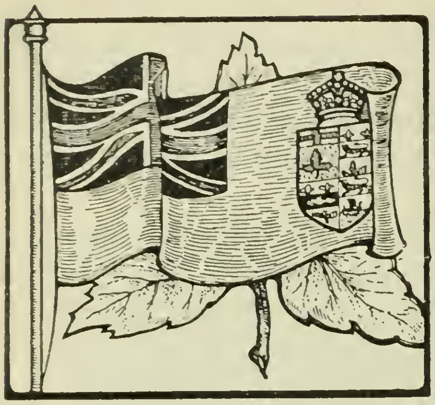
considering the magnitude and ramifications of the work, is a very short time. The many structures and the nature of the territory through which the different channels run has made this one of the really important engineering undertakings of the age, and the construction details have been the most extensive, the plans alone being some of the most elaborate and complete ever drawn up for any large construction work.

The cost of handling freight on the railroads, before recent increases went into effect, varied from 2 to 7 mills per ton per mile, the average being between 3 and 6 mills per ton-mile. It is now estimated that this figure will be reduced more than one-half on the new Canal system, owing to the larger barges and the thoroughly up-to-date facilities. The method of propulsion used is either by power boats driven by steam, electricity or the internal combustion engine, and it has already been determined from trial trips that the speed which may be maintained throughout the system is considerably in excess of that maintained by ordinary freight trains either in normal times or under present conditions.

Many think that the lack of terminal facilities was the chief cause of the decadence of traffic on the old Erie Canal. It is undoubtedly true that the reason for the great amount of traffic through Duluth on Lake Superior is due to the loading and unloading facilities at that port. The Barge Canal Terminal Commission, therefore, recommended that the Barge Canal be provided with adequate sheds and machinery for the purpose of loading and unloading cargoes and storing the goods received. This plan has met with approval, and the Barge Canal will be provided with a system of public terminals which, in the minds of many, will do much to win back to the waterways a great amount of traffic.

At Buffalo there will be two large public terminals, fully equipped with modern freight-handling devices. Lockport and Tonawanda will be provided with two terminals each, while Rochester, Syracuse, Utica, and Albany will have extensive systems. Furthermore, nearly every town or village along the route will have storage sheds, loading machinery and paved wharfs to meet the requirements of traffic. In the city of New York, where nearly $10,000,000 will be expended on canal terminals, there are thirteen either under construction or partly planned, while other sites are being considered. At Troy a permanent quay wharf 1,000 ft. long has been built along the waterfront of the Hudson River. On this improved wharf the State of New York is building transfer sheds, and will instal a portable crane of two-ton capacity, electric portable conveyors for transferring freight from the boats to freight cars, together with travelling derricks and other unloading machinery. Several railroads entering Toy have already adjusted their tracks to make physical connection with this improvement.

The New York Barge Canal offers a solution of many of our transportation problems. This waterway—and it may be called the most important canal in the United States—has been thrown open at a time when its usefulness can be fully appreciated, and when it can fulfil a mission not dreamed of by its original projectors. It can easily carry a total of 10,000,000 tons of freight and this is as much as can be carried on one-fifth of all the freight cars on all the rail lines in the United States. It is equivalent to what could be carried on a string of freight cars which, if placed end to end, would extend from Denver to New York City.



PROPORTIONING THE MATERIALS OF MORTARS AND CONCRETES BY SURFACE AREAS OF AGGREGATES.

By CAPT. LLEWELLYN N. EDWARDS,
Supervising Engineer of Bridges, City of Toronto, Ont.

Continued from February issue, page 73.

MATERIALS USED IN TESTS.

The properties of the cement, of the sand and stone aggregates, and of the water used in the preparation of test specimens were as follows :

Cement.—The Portland cement was, with the exception of that used in the "Consistency Tests," a combination of two brands—namely, "Canada" and "Pyramid." The former was manufactured by the Canada Cement Co., Ltd., Montreal, Que., and the latter by the St. Marys Portland Cement Co., Ltd., St. Marys, Ont. The two brands were thoroughly mixed by first pouring them together from separate receptacles, then by sieving them several times through a No. 20 sieve.

Following are the physical properties determined in accordance with the Standard Specifications and Tests for Portland Cement of the Society for Testing Materials :

PHYSICAL PROPERTIES.

Constancy of volume	O.K.
Specific gravity	3·12
Initial set, minutes	195
Final set, minutes	450
Fineness :	
Per cent. retained on No. 100 sieve	3·8
Per cent. retained on No. 200 sieve	21·8
Tensile strength, lb. per sq. in. :	
Neat, 24 hours	312
Neat, 7 days	677
Neat, 28 days	707
Mortar, 7 days	265
Mortar, 28 days	388

Sand.—All sand used in the tests was of limestone origin, and with the exception of that in one concrete test was secured from the Lake Shore Sand & Gravel Co., Ltd., Toronto, Ont. This sand was dredged from a deposit in Lake Ontario, and was free from clay or other deleterious matter. Its chemical composition was as follows :

Loss on ignition, per cent.	16·51
Silica, per cent.	42·81
Iron and aluminium oxides, per cent.	11·76
Calcium oxide, per cent.	24·47
Magnesia, per cent.	1·68

The specific gravity of this sand taken at 70° F. was 2·689.

The original sand was thoroughly dried upon a metal heater and, to remove the larger material, was passed through a sieve having 4 meshes per linear inch. All material passing this sieve was then divided into the portions retained upon a standard set of 8-in. diameter hand sieves having 8, 10, 20, 30, 40, 50, 80 and 100 openings per linear inch. The portions secured were placed in bags and carefully labelled for identification.

The sands used in concrete tests were not sub-divided as above described, and, in consequence, they contained small percentages of "dust" passing a No. 100 sieve.

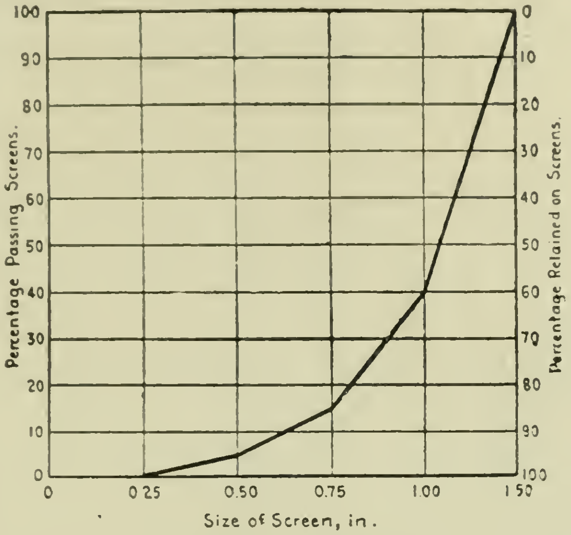


FIG. 4. GRADING OF BROKEN STONE.

Stone.—The crushed stone used in the concrete tests was a composite lot secured from several quarries in Ontario. It was, in general, a dark coloured limestone of good quality. Prior to use, this material was divided into the portions retained upon 1, $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$-in. screens. No material was larger than that retained upon a 1-in. screen. The grading of the stone as used is shown graphically in *Fig.* 4. Its weight was 87 lb. per cu. ft.

Water.—All water used in the tests was taken from the city water mains, the source of supply being Lake Ontario. The chemical analysis is as follows :

	Parts per Million.
Total solids	120·0
Alkalinity (lacmoid) bicarbonates 103 ; carbonates 2	105·0
Permanent hardness	32·5
Total hardness	137·5
Silicious matter	3·84
Iron oxide, alumina and phosphates	0·17
Lime (CaO)	43·4
Magnesia (MgO)	12·2
Sulphates (SO_4)	18·5
Chlorides	9·0

COMPOSITION AND PREPARATION OF TEST SANDS.

The grading of the sands used in the tests was not predetermined. In combining the portions retained upon each sieve an effort was made not only to provide a range of gradings comparable with the usual gradings of natural sands, but also to include a few rather irregular or "freak" gradings. Table V. gives the gradings of the test sands. Several of these gradings are shown graphically in *Fig.* 5.

Fig. 6, reproduced from photographs of the fractured surfaces of mortar cylinders, gives a general idea of the range of sand gradings used in the tests.

Table V.—Grading of Test Sands

Sieve Passed and Retained on.	Percentage Retained on Sieve.																
	Sand Letter.																
	A	B	C	D	E	F	G	H	I	J		L	M	N	O	P	Q
P 4 – R 8	15.0	25.0	5.0	25.0	0.0	10.0	30.0	0.0	0.0	8.0	10.0	15.0	8.0	14.0	11.0	11.0	9.5
P 8 – R 10	5.0	5.0	5.0	5.0	0.0	5.0	5.0	10.0	10.0	5.0	6.5	7.0	3.0	8.0	5.0	5.5	5.0
P 10 – R 20	25.0	23.0	15.0	15.0	0.0	18.0	30.0	25.0	25.0	22.0	16.0	22.0	11.5	21.0	16.0	18.0	19.0
P 20 – R 30	15.0	12.0	15.0	5.0	0.0	11.5	15.0	20.0	20.0	10.0	7.0	12.0	7.0	8.0	10.5	13.0	14.5
P 30 – R 40	15.0	15.0	15.0	5.0	0.0	18.0	10.0	15.0	15.0	14.0	16.5	14.0	10.5	12.5	15.5	16.0	20.5
P 40 – R 50	10.0	8.0	20.0	20.0	36.0	21.0	4.0	15.0	15.0	20.5	21.0	15.0	26.0	15.5	18.0	15.0	18.0
P 50 – R 80	10.0	8.0	20.0	20.0	52.0	15.0	4.0	10.0	10.0	20.0	21.5	13.0	32.0	19.0	20.0	15.5	12.0
P 80 – R 100	5.0	4.0	5.0	5.0	8.0	1.5	2.0	5.0	0.0	1.5	2.0	1.0	2.5	2.0	2.0	4.0	1.0
P 100	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	101.0	100.5	99.0	100.5	100.0	100.0	101.0	100.0

The grading of a test sand having been decided upon and the quantities of the component sizes having been computed and weighed, a uniform composite sand was produced by hand mixing.

As previously mentioned, the sands used in concrete tests were not subdivided into their component sizes.

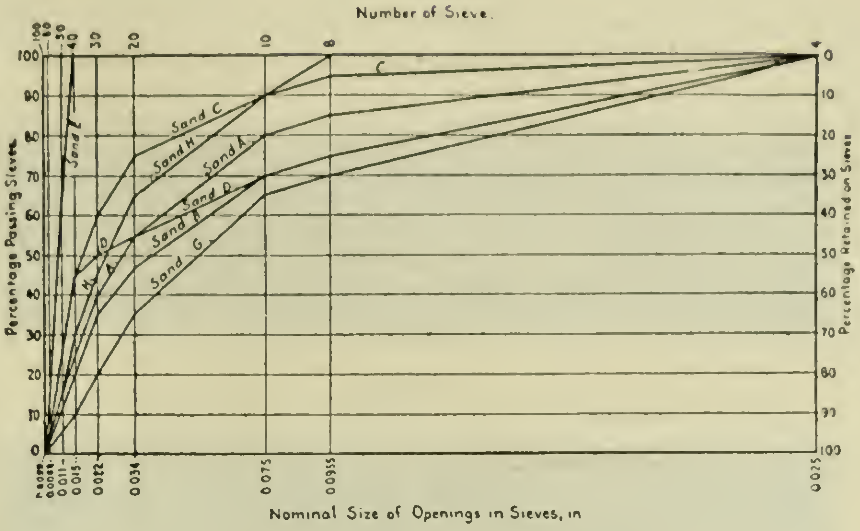


FIG. 5. GRADING OF TEST SANDS.

TEST SPECIMENS AND TESTING.

The test specimens made in connection with the various tests were as follows:

1. For the mortar consistency tests, standard briquettes only.
2. For the mortar strength tests, standard briquettes and cylinders 2 in. in diameter by 4 in. long.
3. For the concrete tests, cylinders 6 in. in diameter by 12 in. long, and from the mortar content of the excess concrete cylinders 2 in. in diameter by 4 in. long.

All test specimens of mortar consistency and mortar strength tests were tested at the municipal laboratory of the city of Toronto. All concrete test specimens and the mortar test specimens made in conjunction with them were tested at the testing laboratory of the Hydro-Electric Power Commission of Ontario, Toronto, Ont. In both laboratories the testing machines used were manufactured by the Tinius Olsen Testing Machine Company, Philadelphia, Pa.

In all compression tests a spherical seated bearing block was used and the ends of the specimens were bedded with sheets of beaver board to secure an even distribution of the load.

In all mortar tests, except the so-called " consistency tests," four 2-in. cylinders and four " standard " briquettes were tested at each age of 7, 30 and 60 days. Only briquettes were used in the mortar consistency tests. In the concrete tests five specimens were tested at each age.

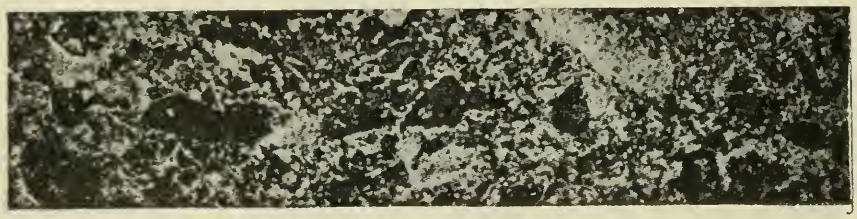
For all tests the maximum load at ultimate failure was recorded.

PREPARATION OF TEST SPECIMENS.

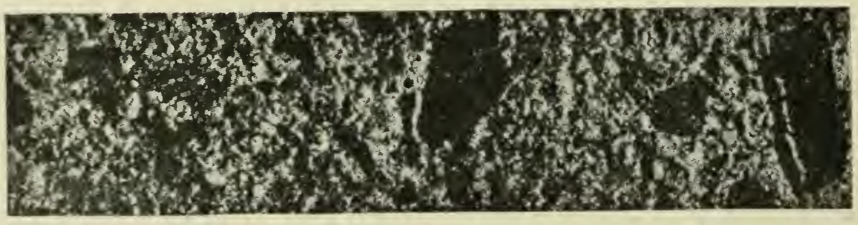
In the preparation of test specimens a special effort was made to do the work with the greatest dispatch, consistent with the securing of uniform results. The mixing of the materials and the making of test specimens was the work of two operators.

Mortar Proportioning, Mixing and Moulding.—Proportioning the cement content of a mortar in relation to the surface area of the sand used is in no way directly comparable with the commonly used method of proportioning by volume the quantities of cement and sand. A " standard " 1 : 3 Ottawa sand mortar, as used in cement testing, was computed to contain 1 g. cement to 13 sq. in. of surface area. This ratio of proportion was used in many of the tests.

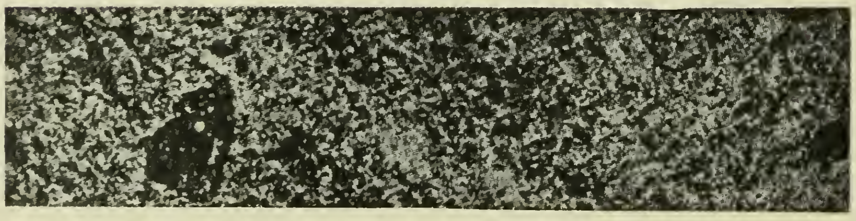
The computed relation of the cement content to the surface areas of several sands assumed to be combined in mortars of 1 : 1½, 1 : 2, 1 : 2½, etc., mix by volume gave a suggestion as to the range of cement content to be used in tests intended to



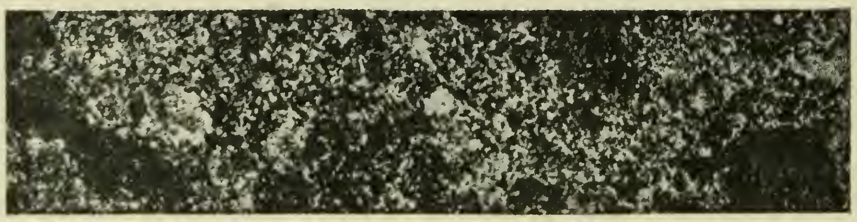
(*a*) Sand A.



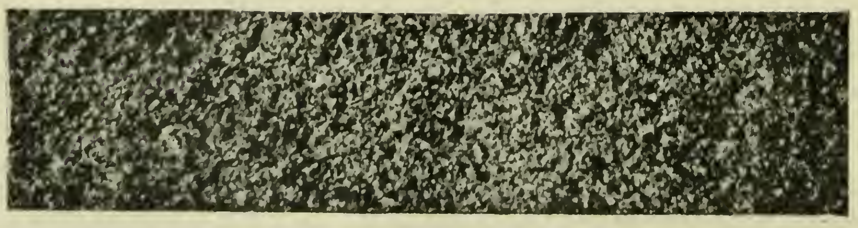
(*b*) Sand B.



(*c*) Sand C.



(*d*) Sand D.



(*e*) Sand E.

Fig. 6. Texture of Mortars (×4).

show the relation of strength to the surface area assumed to be covered per unit of weight of cement. This led to the adoption of the proportions, 1 g. cement to 10, 15, 20 and 25 sq. in. of surface area for such tests.

All mixing of mortar and moulding of test specimens was in accord with the Standard Specifications and Tests for Portland Cement and Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars of the Society for Testing Materials. The consistency of mix used was determined by special investigation. See " Mortar Consistency Tests."

Concrete Proportioning, Mixing and Placing.—The materials for concrete were proportioned as follows :

Cement, 21·12 lb. per 1,000 sq. ft. of surface area of sand aggregate (1 g. cement to 15 sq. in. area). For the portion of sand passing a No. 100 sieve the surface area was assumed to be the same as that of an equal portion of material passing a No. 80 and retained upon a No. 100 sieve.

Sand and stone aggregates, 1 part sand to 2 parts stone by volume.

In order to secure greater uniformity these volumes were reduced to a unit weight basis. These unit weights were as follows :

1 cu. ft. sand assumed at 100 lb.
1 cu. ft. stone assumed at 87 lb.
1 cu. ft. water assumed at 62·37 lb.

The water content of the mix was sufficient to produce a saturated, sticky, semi-plastic mortar showing no free water.

It will be noted in the above that in the proportioning of the cement content of the mix no account was taken of the surface area of the stone aggregate. At the time of making the test specimens the approximate areas of broken stone and gravel aggregates had not been determined.

The concrete was mixed by hand. The cement and sand were first incorporated to form a mixture of uniform colour. Water was then added to form a mortar, into which the broken stone, after it had been surface moistened, was shovelled and the mixing of the entire mass continued until the particles of stone aggregate were thoroughly coated with mortar.

In the puddling of the concrete in the forms special attention was given to the uniform distribution of the broken stone and mortar. Bars having a diameter of $\frac{5}{16}$ to $\frac{3}{8}$ in., flattened to form a comparatively thin blade-like end, were used to secure this distribution. Compacting and the exclusion of entrapped air were mainly accomplished by lightly rapping the exterior surface of the forms with a wooden mallet.

From the excess concrete remaining from each batch after the 6-in. cylinder forms were filled an amount of mortar sufficient to fill twelve 2-in. cylinder moulds was secured. The larger stone particles of the concrete were removed by screening upon a $\frac{3}{8}$-in. screen.

The forms were removed from the test specimens 48 hours after filling. As soon as removed from the forms the concrete test specimens were marked for identification and placed in storage, where they were moistened three times per day by spraying, until required for testing. The mortar-cylinders, upon their removal from the moulds, were immersed in water.

MORTAR CONSISTENCY TESTS.

The marked influence of the consistency of the mix upon the ultimate strength of mortars renders it especially important that test mortars be made of uniform consistency. The importance of this investigation, as a preliminary to the making of tests tending to prove or disprove the validity of the primary theory of the surface-area method of proportioning, is self-evident. Tests were therefore made with the object of developing a means of securing uniformity of consistency in accord with the secondary or consistency theory of this method of proportioning; that is, " The amount of water required to produce a normal, uniform consistency of mortar is a function of the cement and of the surface area of the sand aggregate to be wetted."

It is useless to even outline the preliminary tests made: suffice it to say that only trial or so-called " cut and fit " methods were found to be applicable. As a result of the preliminary tests it was found that " normal," uniform consistency mortars of varying cement content and of varying sand gradings were produced when the quantity of water used in the mix was made equal to (1) that required to reduce the cement to a normal consistency paste, plus (2) an amount equal to the surface area of the sand in square inches divided by 210, that is,

$$\text{Water (cc.)} = \left(\begin{matrix}\text{Weight of cement (g.)} \times \text{Percentage required} \\ \text{to produce ``normal'' consistency paste}\end{matrix}\right) + \frac{\text{(Total surface area of sand (sq. in.).}}{210}$$

With a water content determined by the above equation each of the five test sands J, K, L, M and N, described under heading " Composition and Preparation of Test Sands " (see Table V.) was used in the preparation of two test mortars having cement contents proportioned 1 g. cement to 10 sq. in. sand area and 1 g. cement to 15 sq. in.

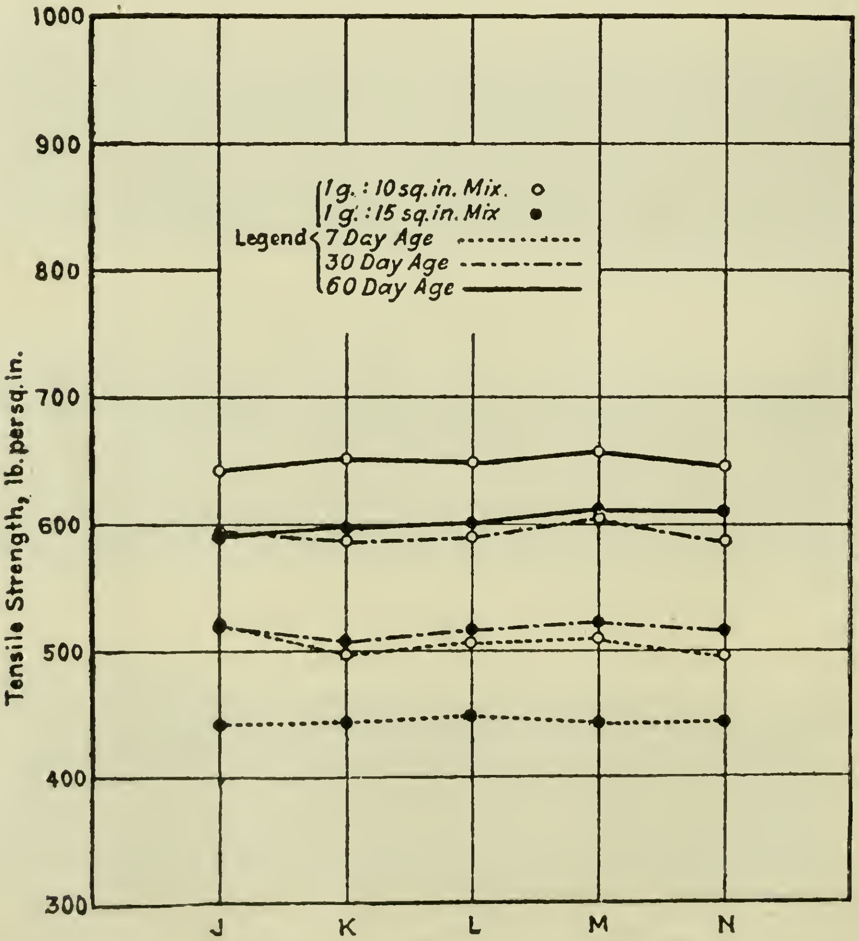


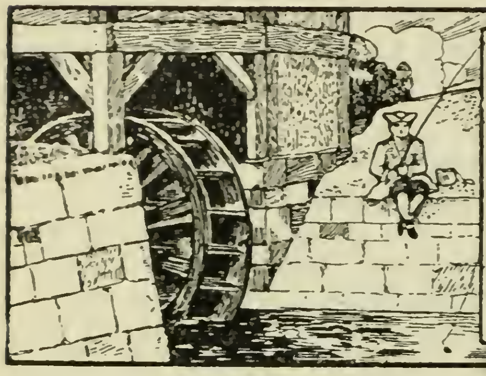
FIG. 7. CONSISTENCY TESTS.—TENSILE STRENGTHS OF MORTAR BRIQUETTES.

sand area, respectively. The composition of these mortars is shown in Table VI. Standard briquettes for tension tests were made from each mortar. The strengths of these briquettes are shown in *Fig.* 7.

TABLE VI.—CONSISTENCY TESTS: COMPOSITION OF MORTARS.

Sand Letter.	Surface Area per 1000 g., sq. in.	Cement Content 1 g. : 10 sq. in.		Cement Content 1 g. : 15 sq. in.	
		Cement, g.	Water, cc.	Cement, g.	Water, cc.
J	7151	715.0	193.0	477.0	140.0
K	7301	730.0	197.5	487.0	143.5
L	5745	574.5	155.0	383.0	112.5
M	8811	881.0	238.0	587.5	172.5
N	6498	650.0	175.5	433.0	127.5

(To be continued.)



THE HOUSING PROBLEM.

Extract from the Report issued by Sir J. Tudor Walter's Committee, appointed by the Local Government Board to consider Questions of Building Construction in connection with the Provision of Dwellings for the Working Classes.

Continued from February Issue.—ED.

FLOOR COVERINGS.

236. The extensive use of concrete in place of wooden joists for ground floors has already created a demand for a form of floor covering more suitable than boards for attaching to concrete ; should the scarcity of timber result in the extensive adoption of concrete floors for the upper storey also, this would still further increase the value of the quest for such new type of floor finishing. A large number of compositions, many of which were based on magnesite, have already been used ; when properly and successfully laid they have proved serviceable, but sufficient failures have occurred to suggest that the conditions of their successful use are not very thoroughly understood ; it is probable that damp in the floors or certain conditions of the atmosphere at the time of laying affect these floor coverings.

Several new compositions have been suggested which are based on other materials than magnesite, and a number of experiments are being carried out with a view to finding a satisfactory solution for this undoubted need. Most of the materials already in use and many of those being experimented with depend on sawdust or fine wood-powder to reduce the conductivity of the material and give a warmer surface than can be obtained with ordinary stone, cement, or tile ; by this means, although floors as warm to the touch as boarded or wood-block floors have not been secured, surfaces about halfway between wood and concrete are attainable. Another proposal is to use a composition something of the nature of linoleum which can be laid *in situ* so as to adhere to the concrete finish of the floor ; this also is the subject of further experiment.

237. It must be recognised that, quite apart from the cost, the newer types of floors offer advantages over timber construction ; the house is rendered more fireproof, and is much easier to keep clean ; vermin are deprived of nearly all opportunity for lodgment ; crevices due to the shrinkage of joists and floor boards in which dust and insects accumulate are entirely eliminated ; these are advantages and suggest the desirability of pursuing the subject. Should no substitutes be discovered which will satisfactorily take the place of wood, it is probable that blocks laid in bitumen on concrete will prove the best alternative ; and for the purpose of making these blocks, certain kinds of home-grown or imported timber might be utilised which are not suitable for other purposes.

238. The conditions of the different parts of the cottage vary to such an extent that one would hardly expect one floor covering to be suitable for all parts. In the living-room, parlour, and bedrooms a warm and quiet flooring is desirable. In the larder and scullery, however, warmth is not important ; a floor which can readily be kept clean, which has no crevices, and which will not suffer either from wet or grease, is specially desirable for them ; for such floors some of the harder red or buff quarries serve admirably and are generally preferred to a plain concrete finish.

ROOFS.

239. The second important question in connection with possible substitutes for timber is the roof work. For this purpose a large quantity of timber is used, and, although it is probable that such timber as may be available from the huts after the war will be more suitable for roofing than for any other purpose, it is quite possible that there may not be sufficient timber for all the roofs which will be required, either from the huttings or from other available supplies.

240. In solving the problem of the timberless upper floor it might be thought that the problem of a flat roof would be also solved. There is, however, this difference, that the roof is exposed to wet and climatic changes, and that a flat roof must be water-tight and should be covered by a material which is not influenced by excessive heat and cold. Such material is not easy to find. Asphalte is one of the most reliable, but it is expensive. A coating of felt bedded in and coated with bitumen, the upper surface being covered with sand or gravel as a further protection, has been recommended as an alternative for asphalte. The difficulties of making a concrete roof water-tight have been overcome in individual instances, but concrete roofs have in so many cases given trouble that on the information at present before us we hesitate to recommend the adoption of such a roof without any other protection against wet. One well-known concrete expert stated that cracks were always liable to form even in good concrete through which damp might penetrate. In addition to the difficulties of making the surface water-tight. the question of condensation on the underside must be borne in mind if concrete is used ; probably this danger would be minimised if a flat roof of hollow brick, similar to the floors referred to above, were adopted, but such floors used for roofing must depend for keeping out the wet on the use of a satisfactory waterproof covering.

241. Other alternatives have been considered ; roofs have recently been constructed in which reinforced concrete beams and spars are employed with comparatively little departure from timber construction ; breeze concrete is used for the whole of the spar or for that part to which it is desired to fix nails, and breeze concrete slabs in place of boarding or laths to receive the slates. It would hardly seem, however, that the methods of construction adapted to wood are likely to prove the most satisfactory ones for utilising such a different material as reinforced concrete, although the simplicity of the method and the small departures from ordinary construction which are involved are great advantages in connection with buildings which have to be erected by local contractors and workmen not used to reinforced concrete construction. If wood is to be replaced by reinforced concrete it seems probable that full advantage should be taken of the additional strength which a structure derives from the rigid fixing together of all its parts, such as that which may be secured in concrete construction, but which is absent when the material is used in the forms of beams and slabs secured with bolts or nails on the lines of timber construction. It seems possible that a form of reinforced concrete " couple " which could be transported in parts and put together on the building job may be devised and standardised, and that, used in conjunction with reinforced slabs, it would prove an economical substitute for timber.

242. The greatly increased capacity for the production of steel in this country, due to war demands, is likely to lead to an extension of the use of steel in place of timber. The development also of electrical and other methods of welding has increased the possibility of utilising light steel members. We have obtained several designs and estimates for cottage roofs constructed with steel principals and purlins, combined with concrete slabs, and have compared them with the costs of timber. Taking the individual estimates, it appears that timber, even at war prices, would usually, but not always, be a little less costly than steel ; we have been much impressed, however, with the reduction in cost of steel roofs, which makers stated could be made if large quantities were ordered at one time. As compared with single roofs, for 500 sets a reduction varying from 25 to 40 per cent. was estimated, and if larger numbers could be standardised as to spans, etc., it is possible that a still further reduction in cost could be effected.

The difficulties which have to be overcome in the use of steel roofs are mainly in connection with the fixing of the slates and the carrying of the bedroom ceilings. Steel principals used with wooden purlins and spars with laths or boarding would hardly save sufficient timber to be worth adopting, and the economical use of steel for roofing would seem to depend very largely on the adoption of some form of slab which will take the slate nails, and will be easily fixed to the steel roofs, and also of some form of slab or fibrous plaster for the ceiling. As an alternative, steel ceiling spars carried on the principals could support metal lathing for the plaster.

Should timber remain sufficiently scarce after the war to necessitate the adoption of some other material for roof construction, we think that steel offers one of the most likely substitutes. It lends itself specially to standardised repeat work, and the work can be designed so that the material is adjusted in strict proportion to the load.

SUBSTITUTES FOR WOOD IN JOINERY.

243. In view of the increased steel production and the probable scarcity of timber, particularly of that kind required for the manufacture of good and durable sashes and frames, and in view also of the economy which could be secured in the manufacture of standardised steel frames and casements, we think it probable that steel may form an effective substitute for timber in this connection.

Steel casements possess certain advantages apart from the question of economy ; they are very durable, especially if strengthened by welding at the corners ; they obstruct less light ; 1 in. of steel would often replace 4 in. of wood ; there is less surface to paint ; they can be readily fixed to brick, stone or concrete walls. Steel casements can be fixed to wooden or concrete frames, or the simple knife-edge frame, which has proved an effective weather check, could be used. The casements are stronger if divided into squares of reasonable size with welded bars. The steel casement is more reliable in exposed positions than those of wood and is free from the defects arising from shrinking, expanding and warping to which the latter are liable.

244. Steel doors and frames have been used to a limited extent. If they could be standardised and produced economically in a form that would meet all other requirements, the advantage of having doors of a material not subject to shrinkage would be considerable.

245. Glazing-bars for skylights have for some time been made of reinforced concrete as a standardised article and would appear to answer satisfactorily. Concrete window-frames suitably reinforced, made to standard patterns and allowed to mature before being fixed, may prove an economical substitute for wooden frames. Certain precautions would need to be taken. The sections must be large enough to protect the reinforcement from corrosion ; on the other hand, the weight of the frame should be reduced to a minimum to allow of easy handling. Secure fixing, both for hinges and fastenings, should be provided in the construction of the frame ; iron plates or nuts would probably need to be inserted in the concrete when the frame was caste These, however, are points for which it would not be difficult to make provision. One advantage of such frames would be the elimination of the difficulty which exists in jointing between the brickwork, stonework, or concrete and wooden frames ; a perfectly sound joint could be made, the jointing edge of the frame being left rough for the purpose, and such facility of jointing might result in some economy in the treatment of the jambs of window openings, particularly in stone walling. Tiles or quarries may be used in place of window-boards even with wooden frames and would be still more appropriate with concrete.

246. Reinforced concrete is an alternative for steel as a substitute for door and cupboard frames. It would have the same advantage of freedom from shrinkage ; there would, in addition, be a firm fixing for plaster and crevices would be avoided. It would, however, be much more difficult to handle.

247. Concrete stairs have been largely used. Concrete has advantages for use in this connection. It is rigid, plaster adheres to it, it forms a reliable ceiling to the space under the stairs, which would remove one objection to the use of such space as a larder. The chief objection to concrete is the difficulty of securing a surface that will not become slippery with use. This difficulty may be removed if the question of a concrete floor covering should be satisfactorily solved.

248. Other parts for which reinforced concrete or similar material might be used as a substitute for timber may be mentioned. Before the war concrete lintels were found to be as economical as those of wood, while concrete had the great advantage that it did not shrink as the house dried and was not liable to perish by dry-rot. We consider that for plates under the ends of joists, particularly in outer walls, concrete, suitably reinforced to strengthen it for handling, would be much better than timber ; if required to be nailed the concrete would have to be constructed of breeze or other material suitable for the purpose, but in many situations a temporary fillet connecting the joists until the ends are built in would remove all necessity for nailing the joists to the plate. The use of wood in studded partitions was already rapidly decreasing before the war ; the substitution of concrete or plaster slabs for such partitions should be general, as such slabs are more hygienic and economical.

249. In regard to the use of concrete as a substitute for timber and in place of brick or stone for walling, there is reason to think that this will be largely developed in the future. Evidence has been put before us in regard to several schemes for the provision of houses to be erected by firms who propose to specialise in one or other of the various types of concrete construction and to organise the work on a commercial basis. Such firms are convinced that, by the substitution of concrete for many of the materials at present in use, and by the adoption of improved methods of organisation and erection, they will be able to effect considerable economy. Hitherto, in a good many of the proposals for substituting new materials for old, the lines adapted to the old form of construction have been largely followed and sufficient originality has not been shown in developing methods more suited to the new material. If these new materials are to be used economically, it may be necessary to rid ourselves of some of our preconceived ideas as to design and to prepare ourselves for that which is more adapted to the new materials.

250. It must also be remembered that, while the relative strength and efficiency of new materials and methods may be demonstrated by experimental tests on a limited scale, the real economy of any new method or process can often only be determined when experience has been gained from experiments on a sufficiently large scale to permit workmen to get accustomed to the new methods and to form a sound basis for judging some of the less obvious and more indirect circumstances on which economy ultimately depends. We are of opinion that it is very desirable for a few of the more promising of the newer methods of construction to be tested by being adopted for a sufficient number of houses.

A small number of experimental houses might be erected in the first instance to make sure of the efficiency of the methods from all other points of view, and after this had been satisfactorily established, a few housing schemes might be utilised for the purpose so as to give the more extended test necessary to establish the relative economy of the several methods. We therefore recommend that opportunity should be taken of the many housing schemes required immediately after the war to carry out such extended experiments. Useful results would thus be obtained which in the light of the experience so gained might have considerable influence on the economy of later schemes. The preliminary experimental houses might also be used to ensure that the planning and detail arrangements of type houses were entirely satisfactory.

SLATER AND TILER.

251. We are unable to suggest any roof coverings more effective, lasting or satisfactory in appearance than slates and tiles properly used in the districts in which they are found or made. Slates are now holed by machinery at the quarries, a process which eliminates some defective ones and reduces the labour on the building. There has been a tendency in the past to specify certain fixed sizes, which has had the effect of exhausting their supply and increasing their price ; economy would result if some range of size were given, especially on an extensive contract. From the point of view of appearance the thicker and rougher slates of small or moderate size are the best ; these are also likely to be economical in price, and are better to resist excessive heat and cold than the very thin or very large slates. In normal times it is worth while to use composition or copper nails instead of iron ones, which are liable to be eaten through by rust; even when galvanised the driving of the nail through the slates will scrape off the covering and expose enough of the iron to start rusting. Where roofs are not boarded torching should be used; the chief function of the mortar used in torching is to check the wind, which when it has a clear course carries rain or fine snow with it between the slates or tiles; hence large quantities of mortar, which tend to rot the slate laths or battens, are not required.

Experience in Scotland and in exposed situations elsewhere tends to indicate that to render the roof perfectly wind and water-tight it is necessary to use close boarding or sarking and, in some cases, to cover the sarking with a cheap roofing felt. The small slates which are quarried in Scotland and which are generally preferred to the larger Welsh slates are nailed directly on to the sarking. With an improved form of tile it may be possible to use battens and torching with successful results, but the experience of this method has up to the present not been satisfactory in Scotland.

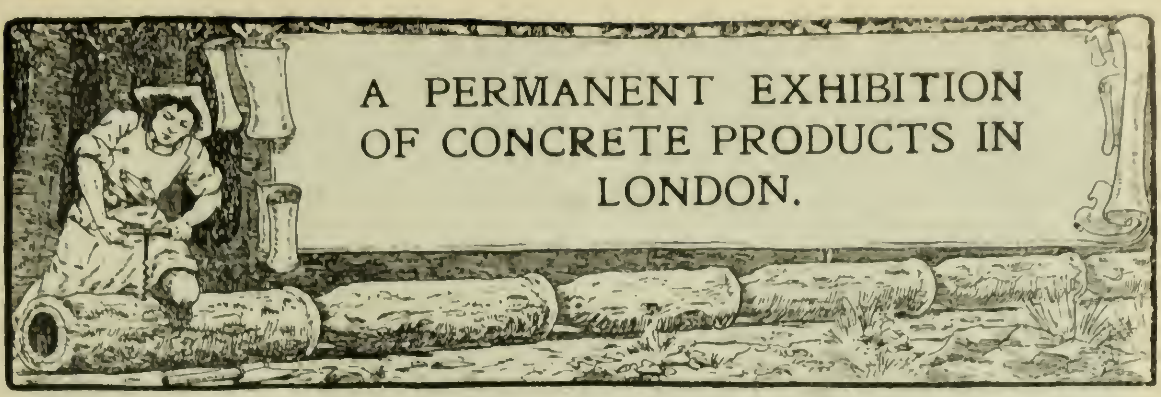
252. Asbestos and cement sheets or slates have been extensively used for covering roofs. They are somewhat lighter than natural slates and much lighter than tiles, but as in either case the covering only represents one element in the load which the roof has to carry, and generally only a fraction of the total load, the saving in timber which can be effected by using the lighter material is less than might be expected; there is, however, some saving, especially as compared with the heavier types of tiling. Asbestos sheets cannot easily be torched, and therefore should be laid on boards, which may add to the cost as compared with slating. There is evidence of fair durability, but time alone can show whether this material can last as long as slates and tiles are known to do. We doubt whether the saving in cost is often sufficient to justify the risk as to permanence and the sacrifice of appearance involved in the use of this material.

CARPENTER AND JOINER.

253. Reference has already been made to the shortage of timber; and possible substitutes have been considered. Moreover, we have sought other means to mitigate the difficulty; the necessity for very careful seasoning of certain kinds of timber required for special purposes during the war has drawn attention to the methods used for artificially drying and seasoning timber, and new light and experience have been gained. It seemed clear from evidence before us that artificial drying and seasoning might be much more scientifically carried out than hitherto, and that the period required for such drying and seasoning might be materially shortened; in this way the output from the existing drying plants might be increased and the whole process rendered more thorough and reliable. We have, therefore, arranged to have experiments made with a view to determining the most expeditious mode of artificial drying and seasoning of timber. At the same time, we have been impressed with the importance of guarding against the introduction of dry-rot. Owing to the depletion of cut stocks and various other causes there is reason to fear that the disease known as dry-rot is becoming an increasing danger. It is important to recognise that it is an infectious disease, and that timber is liable to become infected when stacked in the timber yards or even during the period of its voyage in the ship. There is reason to hope that more scientific methods of drying and seasoning may have the effect of sterilising the germs of this disease; this point is also being investigated, and we hope to embody the results of these researches in a supplementary report.

254. We have considered how far the timber which has been used for hutting and other temporary war purposes could be employed in post-war house construction. In some cases timber of inferior quality has been used; a large quantity, however, was sound, this will have had several years' seasoning and a certain proportion of it should be available; much will depend on the methodical taking down, cleaning and stacking, but there is reason to hope that some of it will be suitable for roof spars and roof boarding. Great care, however, should be exercised in selecting such timbers for use in cottage construction to ensure that unsound, unseasoned or infected wood is not employed.

(*To be concluded.*)



A PERMANENT EXHIBITION OF CONCRETE PRODUCTS IN LONDON.

As our readers will doubtless remember, in an article entitled "The Stone Age in London," which appeared in the June issue of this Journal last year, we gave a brief description of a permanent exhibition of concrete products arranged at 143 Grosvenor Road, S.W.1, by the Concrete Utilities Bureau, whose headquarters are at 6 Lloyds Avenue. During the time which has elapsed since our first notice the collection has been considerably extended and the additions form, in the main, the subject of the present notes.

The first impression received by visitors to this exhibition is the large variety of articles which are being made in concrete, and not the least important function of an educative collection such as this is that the products here on view frequently suggest lines of development in directions which are entirely new.

Railways.—The increasing number of articles made by the railway companies at their own yards for their own use is seen at a glance on looking through the catalogue or on visiting the show-room. Seven railway companies are represented in the collection, viz. :—The Great Western Railway, London and South Western Railway, Great Eastern Railway, Great Northern Railway, London, Brighton and South Coast Railway, North Eastern Railway, and the Cheshire Lines Committee, and the number of different railway products which are exhibited amounts to no less than seventy-four. The greater number of these are examples of the use of concrete as a substitute for timber, but there are also many in which concrete takes the place of iron, steel, brick or stone. There is, of course, no doubt that the recent shortage of building and constructional material has contributed in a large measure to the extension of the uses to which concrete may be applied, but the consensus of opinion amongst railway engineers who have adopted this form of construction is that not only will concrete continue to be employed for purposes already devised but that its use will be very greatly extended.

The evolution of the ideal concrete railway sleeper continues to occupy the attention of engineers and others, and several new types have been produced during the past twelve months. Among the additions to the Grosvenor Road collection we notice a transverse sleeper by Alex. Bruce & Co., of Grays, Essex, accompanied by a skeleton showing the method of reinforcement. No chairs are required with this sleeper, and by an ingenious device the spike which holds the rail down is bent as it is driven into a metal socket and by this means is prevented from working out. This example, which was one of a number laid in 1914 on a private line, was removed for the purposes of this collection in October 1918, the others, laid at the same time, being still in use. This sleeper is shown in *Fig.* 1.

The pot sleeper designed by Messrs. Rendel, Palmer & Tritton, and seen in *Fig.* 2, is at the present time undergoing trial on the Great Western Railway. This block is reinforced with two sets of spiral wires, one set near the top and the other near the bottom. No chair is used, but an oak pad is interposed between rail and block.

Messrs. Trollope & Colls have also contributed a concrete sleeper consisting of a pair of blocks tied by an oak transom. In the example on view, seen in *Fig.* 2, no chairs are necessary, but the blocks can be adapted for chairs if required.

The Meyrick block sleeper, under trial on the London and South Western Railway (see *Fig.* 3), and the yoke-block sleeper in use on the Great Central Railway and the

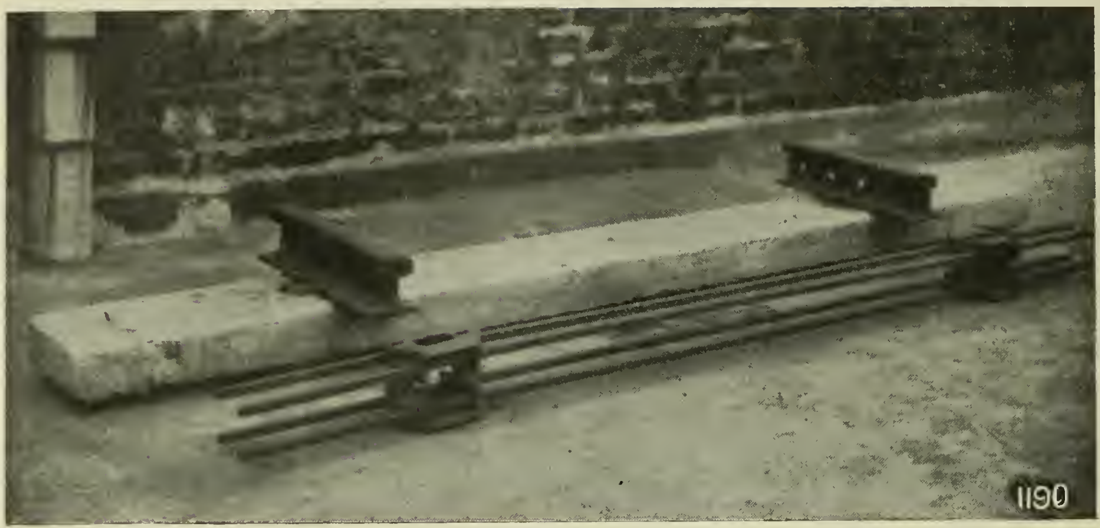


Fig. 1. The **Bruce** Patent Sleeper, in front of which is seen the skeleton showing the method of reinforcement.

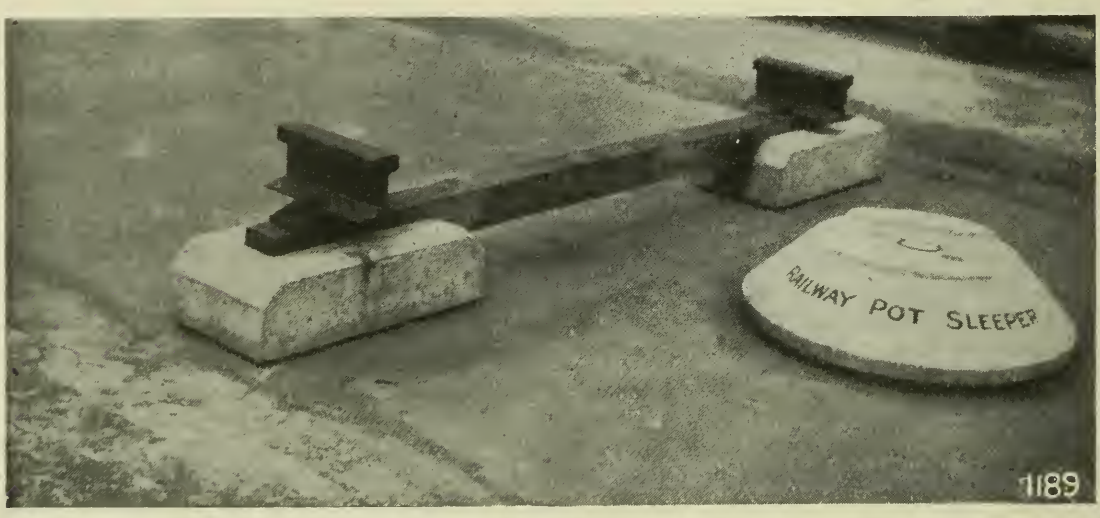


Fig. 2. Messrs. Trollope and Colls's Concrete Sleeper and the Pot Sleeper under trial on the Great Western Railway.

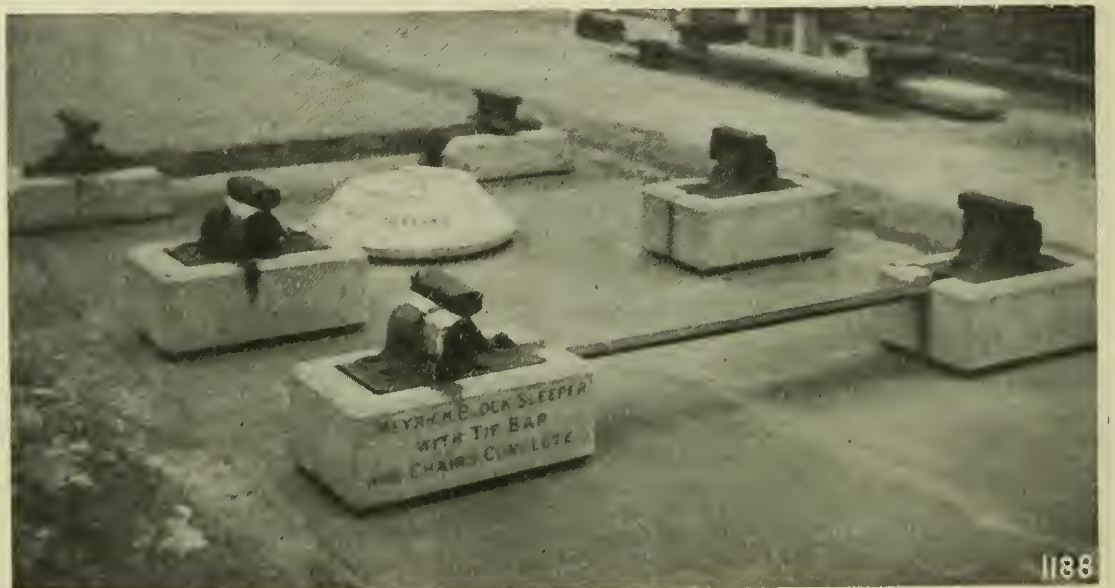


Fig. 3. Group of Concrete Sleepers, the first two pairs being examples of the Meyrick Block Sleeper, one pair of which is provided with a metal tie.

Great Eastern Railway, have already been described in this Journal, but one exhibit, a pair of York pattern yoke sleepers, is of great interest, in that they formed one pair of a number laid in the main North Eastern Railway line near York in 1914, and where, with the exception of those here exhibited, they are still in use.

Space does not permit of our even naming all the articles intended for use on railways, but among the recent contributions the Bridge Number Post and Plate, seen in *Fig. 4a*, and the Distance Posts and Gradient Posts made by the London and South Western Railway Company, may well be mentioned as being novel and suggestive. In these, black concrete letters or figures stand out in relief upon a light-coloured concrete panel supported by a concrete post. The same system is coming into use on some of the railway lines for station name-boards, and we see no reason why street name-plates should not be made in the same way. They would be practically everlasting, no painting would be necessary, and all the attention they would require would be an occasional wash with clean water.

The culvert blocks contributed by the Great Western Railway Company suggest a use for concrete which might be adopted with advantage by County Authorities and others. The blocks are made in two patterns, one for the lower half of the structure and the other for the upper portion ; when they are grouted together they form a culvert having a circular section.

In addition to fence posts, gate posts, gullies, stable paving and drinking troughs, there are many exhibits which are of interest to public authorities. We can refer to a few only.

Roads.—The question of road reconstruction is exercising the minds of engineers and surveyors throughout the land. The model, therefore, of a piece of concrete road will be welcome to those who are interested in this subject. The model shows a portion of the finished roadway, and also the method of reinforcement, the whole being a replica in miniature of the roads laid down by the Port of London Authority, by whom the model was contributed. The construction of one of these roads was described in our January issue. Still more welcome will be a full-width section of reinforced concrete roadway with kerbs and gutters which the Bureau have in contemplation, and which it is expected will be laid at an early date. This section will be so arranged as to show every stage in the process of concrete road construction, and will, it is considered, meet a distinct want:

Municipal Work.—An example of the enterprise of local authorities in the adoption of new methods is seen in the exhibits sent by the Council of the County Borough of Croydon. These include amongst other things a concrete rose ladder such as is used in the public gardens of the borough, which is celebrated for its rose culture ; concrete guard posts perforated for tube railing, and notice board posts. In some of the products made by this municipality, the aggregate consists of crushed clinker from the Council's refuse destructor.

The concrete work, too, carried out by the Borough Council of Aylesbury is represented by a length of well-made kerbing and channelling, of which some 3,000 yards made by the Council's own workmen have been laid during the last seven years.

The channelling is protected by a row of 4-in. by 4-in. stone setts, and the whole is laid on a bed of concrete 4 in. in thickness. The total cost when laid, including setts and bed, was, we learn, 2s. 9¼d. per lineal foot.

One of the most recent products of the same authority is a specimen of concrete pavement gutter for taking the roof water from a house or shop across the pavement to the road channel. These gutters are usually made of iron, so that the adoption of concrete for this purpose means a definite economy.

Two excellent examples of lamp-posts, well finished and artistic, one made by the London and South Western Railway Company and the other by Messrs. Tidnams, suggest an economy which, with the present high cost of iron, might be effected by public and private bodies, and the same might be said of syphons for road drainage, sewer pipes and drain pipes, several examples of which are on view at the Exhibition and are shown in *Fig. 5*.

Building.—The building interest has not been forgotten and the visitor may see various types of slabs and blocks, both separate and built up into walls. Messrs.

Sharp, Jones & Co., of Parkstone, show a set of concrete interlocking roofing tiles, while " Poilite " asbestos and cement tiles and sheets are supplied by Messrs. Bell's United Asbestos Co., and fibro-cement sheets and slates by the Fibro-Cement Works.

Among a number of interesting examples made at the Moulded Stone Department of the Gas Light and Coke Co. is a length of concrete panel fencing,

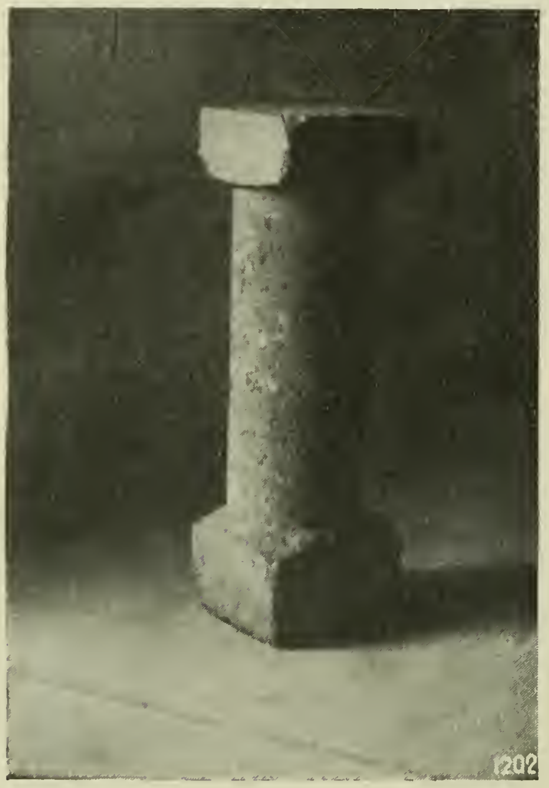


Fig. 4. Sample of Fire-resisting Concrete made of Burnt Gault. The central portion of this specimen has been turned in a lathe.

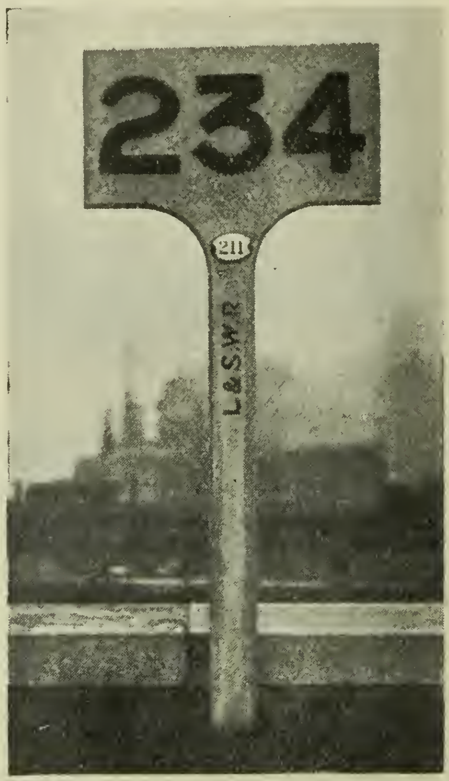


Fig. 4a. Bridge Number Post and Plate of concrete in use on the London & South Western Railway.

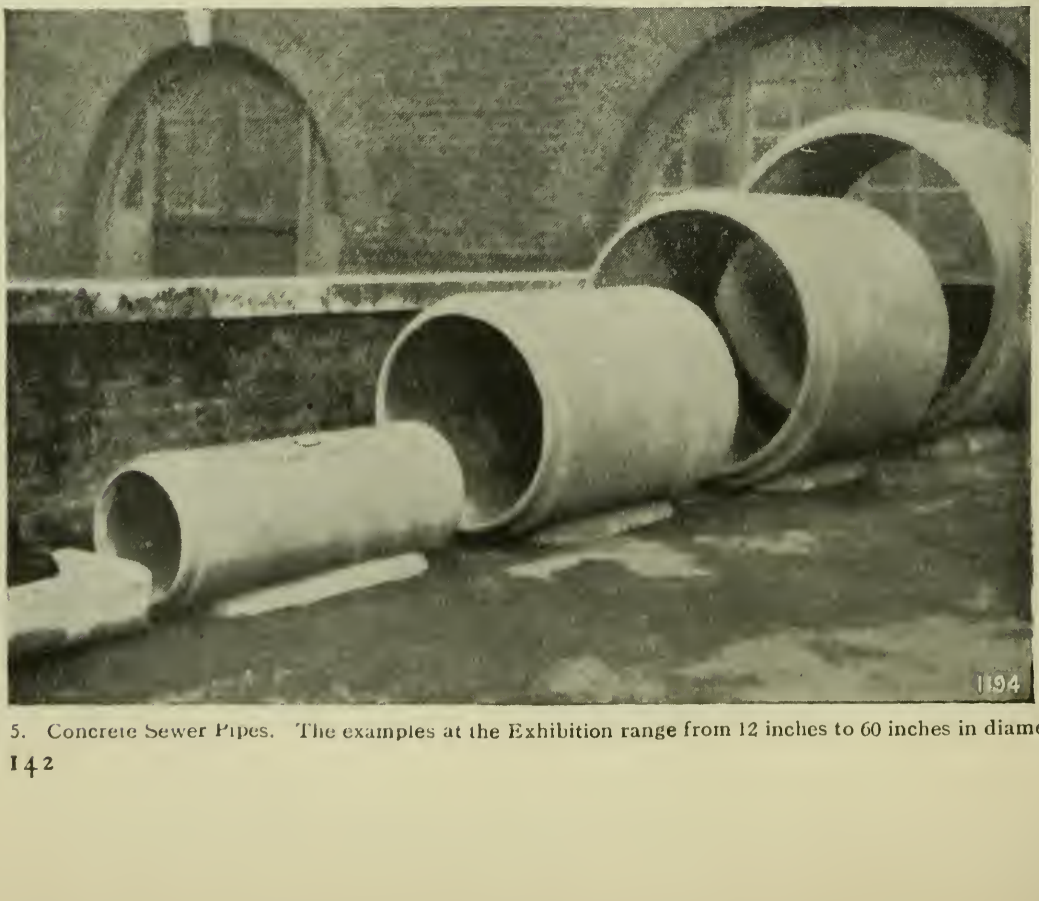


Fig. 5. Concrete Sewer Pipes. The examples at the Exhibition range from 12 inches to 60 inches in diameter.

each panel consisting of combined rails and palings cast in one piece and supported by concrete posts.

A good deal of interest is shown in the chalk concrete building blocks and bricks made by Capt. Quick, and to which reference was made in our last month's issue, while a rather remarkable exhibit is that of a sample of concrete, the aggregate for which is burnt gault. The fire-resisting quality of this concrete is very high and the material is of such a nature that it can be tooled with ease ; the sample in question, which is shown in *Fig.* 4, has been turned in a lathe.

Other exhibits interesting to builders are various small parts which lend themselves to standardisation, such as windowheads, sills, doorheads and thresholds, while the building in which the collection is housed provides an excellent example of concrete floors and columns of great strength.

Agriculture.—In view of the national importance of increased food production, and the attention which will, in the future, be devoted to agriculture, it is not surprising that articles and structures for use on the estate and farm are numerous and varied.

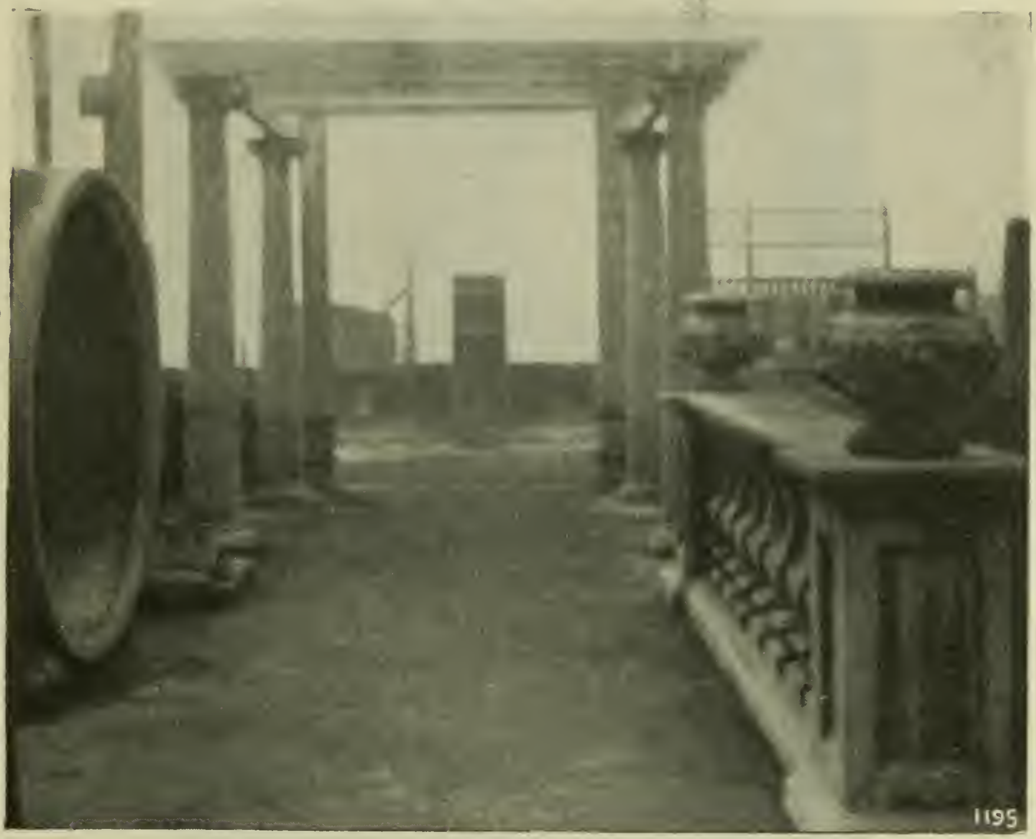


Fig. 6. View in the open-air portion of the Exhibition.

These comprise products of a utilitarian nature, such as troughs and tanks, mangers, stable paving, fencing of many kinds, gate posts, steps, well tubes and a garden frame, as well as many specimens of ornamental work, as, for example, balustrading seen in *Fig.* 6, vases and pedestals, a pergola and specimens of terrazzo.

The well tubes may need a word of explanation. Each tube is a hollow cylinder of concrete whose diameter is that of the proposed well. In sinking the well, one of these tubes, provided with a cutting edge, is placed on the ground in the position selected, and the soil dug out from the inside. As the excavation progresses the tube gradually sinks and another is placed on the top and sunk with it. These operations are continued until the proper depth has been reached Thus the tubes not only assist in sinking the well, but, at the same time, provide a lining for it, whereby the lengthy and often troublesome task of bricking the interior is entirely obviated.

The value of ensilage—a method which is very widely adopted in the United States—is gradually being realised by agriculturists in our own country, and in this connection it is hoped that a concrete silo will shortly be added to the collection.

Artistic Treatment.—There is one aspect of concrete which the vast majority of people utterly fail to realise, and that is the scope which it offers for artistic treatment. Of design in concrete structural work much might be written, but this does not come within the scope of these notes, and for obvious reasons could not be looked for in an exhibition of this character ; but of surface treatment there is no lack of examples which have been a source of surprise to many whose idea of a concrete surface was that it possessed a uniform grey colour and presented little to speak of in the way of texture. The examples on view, which are in the form of panels, show that an infinite variety of pleasing effects, in both colour and texture, may be obtained in concrete by a very simple means—viz., the exposure of the aggregate by scrubbing the face of the material with a stiff brush and clean water while the concrete is green. It will thus be readily understood that by a judicious selection of aggregate any desired colour and texture may be secured. This method, which may also be applied to concrete blocks, should appeal to the architect and the builder, and although the treatment may slightly increase the cost of a building, the money is well expended in view of the permanent effects of great beauty which may be obtained.

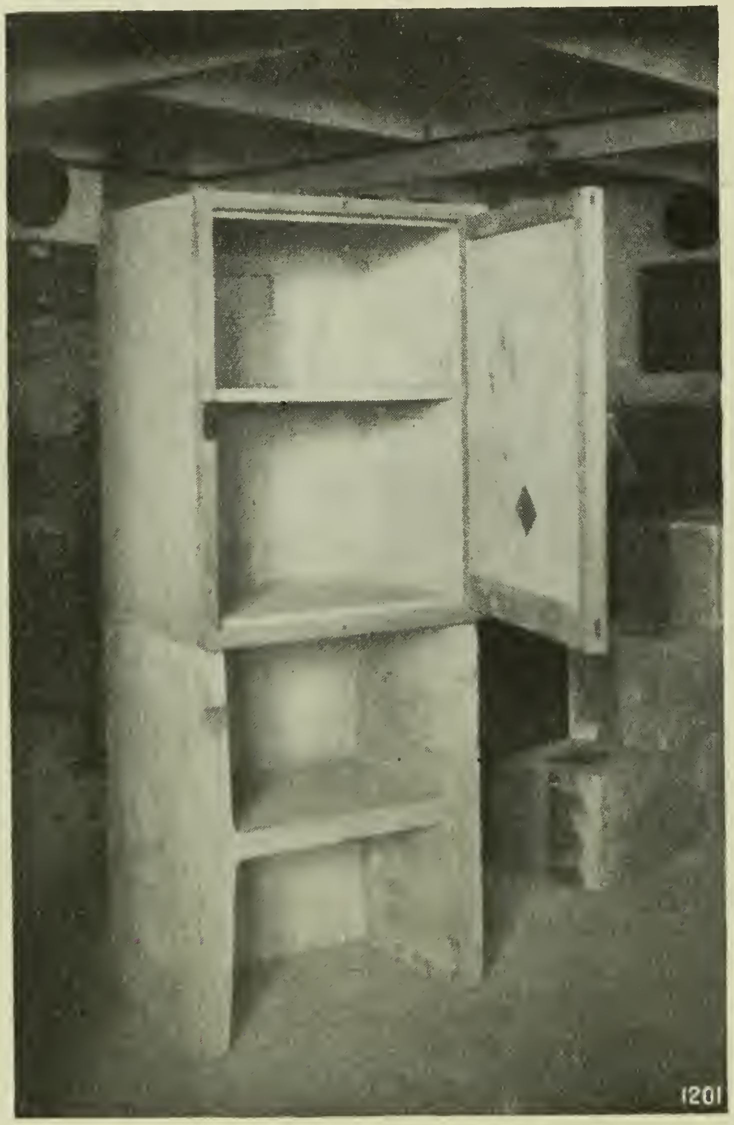


Fig. 7. Concrete Food Locker made by the Gas Light and Coke Company.

Further specimens illustrate the manner in which concrete lends itself to tool work, some of the ornamental panels being indistinguishable from finely carved stone.

These examples are first moulded to the general pattern and afterwards undercut and finished with a tool ; while, in one or two instances, where the design does not involve undercutting, the whole panel has been formed by moulding only.

Decorative Work.—The adaptability of concrete for decorative purposes is being utilised in ecclesiastical architecture. A very pleasing example of this is seen in a quarter-size sample of moulded panelling and tracery contributed by the Stockton Stone and Concrete Co., by whom specimens have recently been supplied to St. Mary's Church, Horden, and to St. Hilda's College Chapel, Durham.

Generally.—One or two other exhibits of a miscellaneous character call for mention.

A structure at once useful and suggestive is a concrete food locker made by the Gas Light and Coke Co., and which is shown in *Fig.* 7. These are very convenient for use in industrial works ; indeed, in some establishments in which a large number of hands are employed, such lockers are made fixtures by being incorporated into the walls. Similar structures on a large scale and provided with hooks cast in the concrete are used as meat safes, and from the meat safe it is but a short step to the cold storage chamber for which concrete is found to be perfectly adapted.

Another exhibit of an unusual nature is a high-tension electric switch-gear cubicle, seen in the distance through the pergola in *Fig.* 1. For this, of course, reinforcing metal cannot be employed.

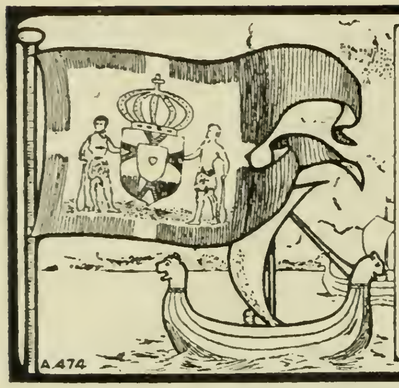
Those who construct concrete greenhouses, garden frames or hot-beds, may desire to use concrete glazing bars, and of these two or three examples are to be found in the collection.

In addition to the actual exhibits mentioned in the catalogue there are on view a considerable number of aggregates which have been collected from different parts of the kingdom, quite a gallery of photographs which give an additional interest to a visit to this unique exhibition, and apparatus by means of which tests of various kinds are, from time to time, carried out.

The scope of this collection may be gathered from the following list of the exhibitors whose names appear in the catalogue : Alexander Bruce & Co., Atlas Stone Co., Banger's Concrete Construction Co., Bell's United Asbestos Co., British Fibro-cement Works, Gas Light and Coke Co. (Moulded Stone Department), Mr. H. Kempton Dyson, W. H. Lorden & Son, Old Radnor Trading Co., Patent Impervious Stone Co., Patent Victoria Stone Co., Permanent Way Improvements Co., Port of London Authority, Capt. Quick, R.E., Sharp, Jones & Co., Stockton Stone and Concrete Co., Stuart's Granolithic Co., Tidnams Ltd., Trent Concrete Ltd., Trollope & Colls, Wingets Ltd., the Borough Councils of Aylesbury, Croydon, Norwich and St. Pancras, and the railway companies to which reference has already been made.

The aim of the Concrete Utilities Bureau in assembling this collection of concrete products is entirely educational. It was felt that there was a distinct need for such a collection in order that those actually or potentially interested in concrete might be provided with the means of acquiring a knowledge of the multiplicity of uses to which concrete may be applied or of extending such knowledge as they already possessed ; and also that experienced concretors might have an opportunity of comparing their own methods and results with those of their fellow-workers, and we certainly are of opinion that such a collection as this, which never can be complete, goes far towards meeting this need and makes for progress and for the advancement of knowledge.

To all who are interested in concrete a cordial invitation is extended to visit this exhibition, which is open daily from 10 to 4 (Saturdays excepted).



THE REINFORCED CONCRETE DOME OVER THE NEW HIPPODROME at COPENHAGEN

By ERNEST G. W. SOUSTER.

The following is a short description of an interesting example of the application of reinforced concrete to dome construction in Denmark.—ED.

THROUGHOUT the ages the construction of domes has been a sign of an advancing civilisation, and the methods by which they shall be constructed has been the subject of interest not only to architects and engineers, but, as in the famous Duomo of Florence, of the whole population of the city.

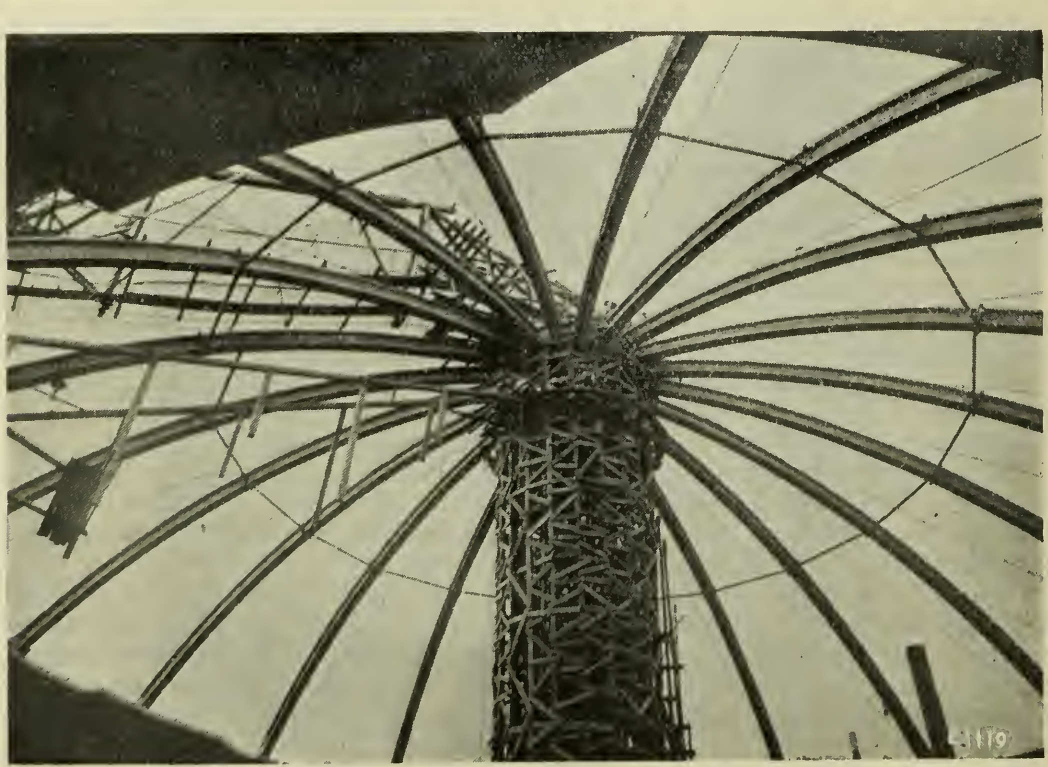


Fig 1. Reinforced Radiating Ribs in position.
DOME OVER HIPPODROME AT COPENHAGEN.

To construct a dome on a solid centering is a comparatively simple matter, and it is therefore of interest to state that this example, which is entirely of reinforced concrete (a material in which the centering is the chief objection raised against its use) was constructed with far less timber work than would have been required for a dome of stone or brickwork.

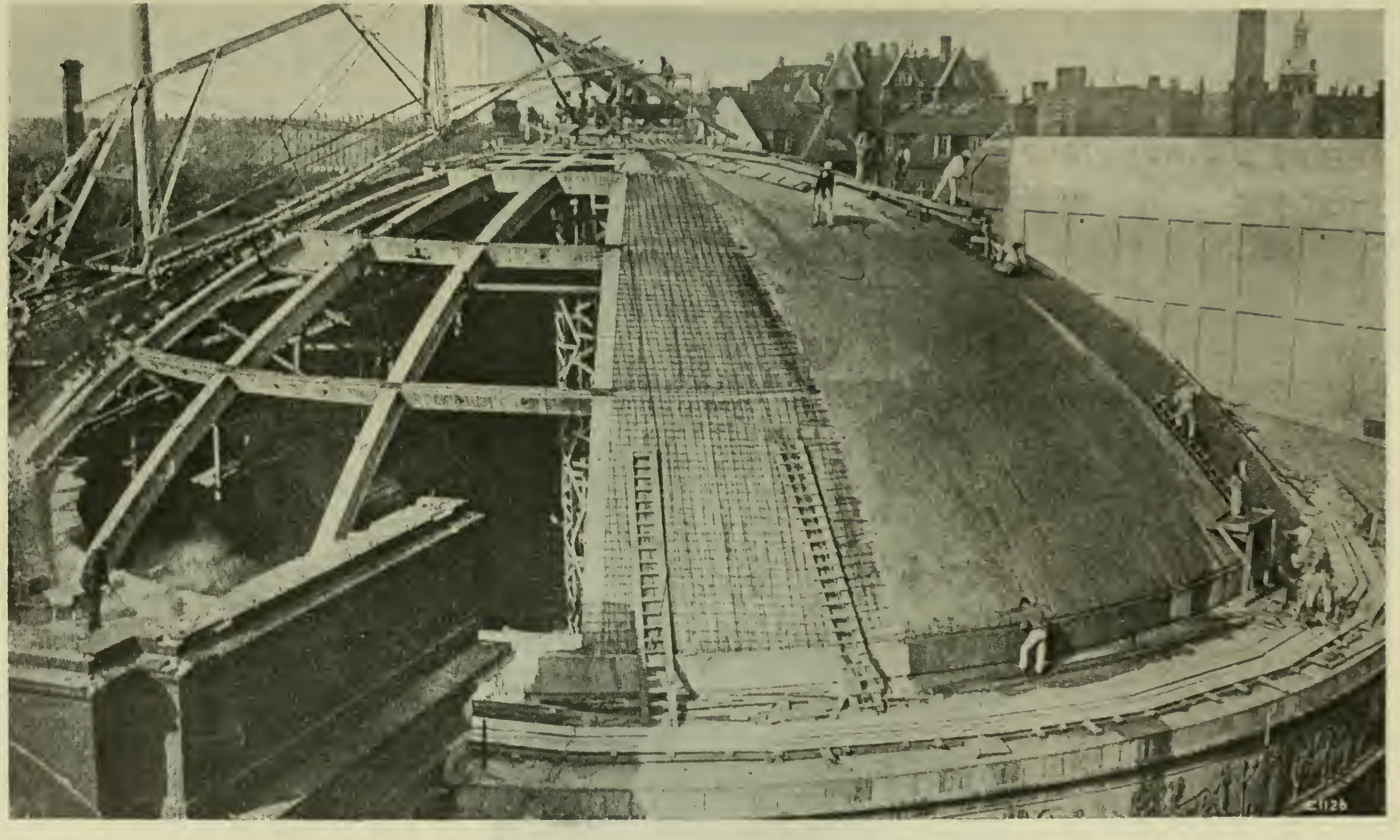


Fig. 2. Showing Ribs in position and Reinforcement of Panels.
Dome over Hippodrome at Copenhagen.

The dome which covers the new Hippodrome at Copenhagen has a span of 130 feet, and approximates more to saucer than basin form, which incidentally means greater normal thrusts on the outer or containing walls of the building.

Its method of construction is shown in Figs. 1 and 2. In the exact centre a timber gantry tower was built, and on and around it a continuous reinforced concrete apex ring was formed, whilst a springing ring was constructed on the top of the containing wall of the building.

The dome itself is formed on a system of radiating ribs or arched beams filled in with reinforced concrete panels or slabs. The ribs, of which there are 20, are of H section, and were constructed on the ground and hoisted into position. Between them three rings of stiffening beams were constructed, and are seen in Fig. 2, and the 89 intermediate bays were formed as simple panel fillings with reinforcement both ways and across diagonals.

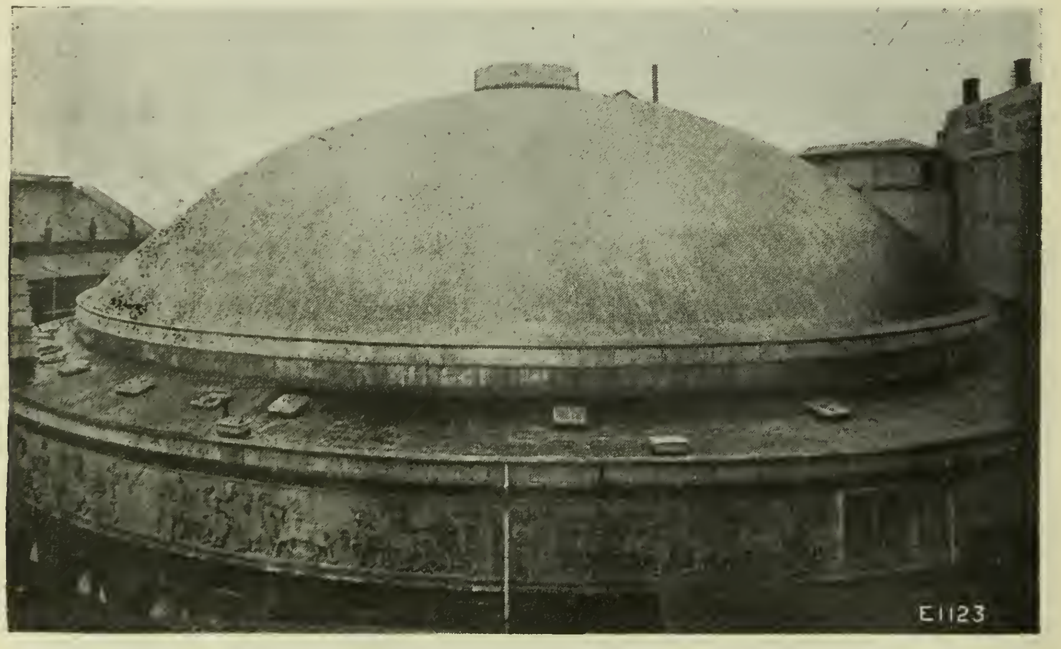


Fig. 3. The Completed Dome.
DOME OVER HIPPODROME AT COPENHAGEN.

The completed dome, which is finished with asphalte, is shown in Fig. 3, and the whole of the concrete work was designed and executed by Messrs. Christiani & Nielsen, of 25, Victoria Street, Westminster, S.W.

A NEW FORM OF REINFORCEMENT.

The following is a short abstract from a description which appeared in "Le Genie Civil."—ED.

M. Charles Rabut, a retired inspector of the French bridges and roads, has recently presented a paper to the Académie des Sciences in which he proposes a new form of reinforcement for concrete, which consists in substituting thin flat or curved plates or tubes for the bars and rods now in use.

The present use of three courses about a given point is always superfluous as three tri-orthogonal tensions can be arranged in two perpendicular planes, one of which possesses only one degree of freedom; these two planes should therefore contain the two principal tensions, one of these being the largest of the three under consideration and the two other tangential to a third virtual course, so as to form an ideal reinforcement by means of a system of triple orthogonal surfaces, especially as each of the three courses may be real in some areas and virtual in others according to the position of the external forces.

In a structure where the three principal forces are tensile it is desirable to combine a course of bars with a plate, each point in the combination being so fixed that the bars are placed in accordance with one of the principal tensions and the plate in accordance with the two others.

The use of plates, as proposed by M. Rabut, has the following advantages :—

(i.) A saving in the labour required to place a given weight of metal in position.

(ii.) A greater stability before and during the placing of the concrete.

(iii.) Use of the resistance of the internal forces in the structure in two principal directions instead of only in one as hitherto.

(iv.) In the case of a plate covered on both sides with concrete, the two faces are independent of the direction of the total tangential force.

(v.) In the case of plates covered on only one side, the maximum resistance is obtained by the removal of the neutral axis to a maximum distance, the suppression of the dead zone (*i.e.*, the zone of material between the reinforcement and the surface), which never possesses the same strength as the remainder of the structure, the protection of the concrete from shocks, chemical corrosion and infiltration and the use of the reinforcement as part of the form or shuttering.

(vi.) The possibility of increasing the adhesion by soldering or welding the bars to the plate in a transverse direction to the tangential forces and to the pressure on the concrete.

(vii.) The ease with which the use of concrete may be avoided in parts where metal alone will suffice, as in the case of concrete tubes, where the metal acts in accordance with its longitudinal adhesion and transverse tension.

M. Rabut's experience with concrete reinforced with tubes or plates shows :—

(*a*) The forces acting on the tube may be calculated by the ordinary rules.

(*b*) There is no need to consider the resistance of the filling, as it has, naturally, sufficient resistance to compression. Hence, lean concrete or even sand may be employed.

"Tubed concrete" is specially useful for the economical construction of structures heavily loaded at the end, for the pylons of suspension bridges, aerial hangars or stations, wireless stations or large viaducts. This is quite distinct from the use of piles and tubular foundations in which the tube or column carries the load directly.

For structures with simple curves the reinforced bars may usually be replaced by a piece of thin sheet iron which is filled with concrete.

A very important application of this new reinforcement is for railway sleepers, for in all such articles there is an enormous advantage in doing away with the reinforcement of the neutral axis, inasmuch as it also obviates on the dead zone, which may be ½ in. to 2 in. thick, only a total thickness of 2½–6 in. Reinforced planks made by the new arrangement seldom need any other reinforcement other than a fixed band of metal, which also serves as a mould. The shells of boats can be designed on the new system in an equally simple manner. Curved structures under longitudinal compression, such as dams, reservoirs, or retaining walls, should consist of a concrete wall reinforced by a plate or sheet—which serves as a form and ensures ample resistance to water—provided with reinforcing bars placed in the direction of the flow of the water or pressure. In the opinion of M. Rabut, such a construction will put an end to the disastrous breakdowns which occur at intervals in barrages built on older ideas of reinforcement.

MEMORANDA.

The Use of Colour in Concrete Stone.—It is stated in *Concrete*, U.S.A., that manufacturers of concrete stone are very careful in the use of mineral pigments for colouring purposes and "usually strive for soft mellow tones, mere suggestions of colour, sometimes merely escaping whiteness, slightly softening the whiteness produced with light aggregates and white cement. One such manufacturer puts the limit of 35 lb. of colour to 25 cu. ft. of stone, which is approximately 35 lb. of colour to 600 lb. of cement, or about 1 to 17. Most of the colour so used is yellow ochre. Many different effects are produced with the same colours and only a few aggregates, by different blendings. Chief reliance, at all events, should be on the aggregates."

In placing hollow tile and concrete joist floors the tile should be thoroughly sprinkled before the concrete is placed, otherwise the concrete will set first over the tile, leaving depressions or even shrinkage cracks in the tops of the joists.

Telegraph Poles of Reinforced Concrete.—Telegraph poles of reinforced concrete are being developed by a firm in Geneva, and appear to be giving promising results. The poles are built up of sections 20–30 cm. in height, the blocks having vertical holes through which the reinforcement rods are passed, and finally fixed in with cement. Some tests of the poles are described in the *Schweizerische Bauzeitung*, whence it is concluded that they behave just like monolith poles. There is, apparently, no tendency to snap across the joints.

A Gas Producer has been put in service in America in which concrete slabs are used instead of sheet steel for the casing.—*Engineer.*

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

DOVETAIL CORRUGATED SHEETING.

By M. NOEL RIDLEY, M.Inst.C.E.

The following is a short abstract from a paper read at the Eighty-Fourth Ordinary General Meeting of the Concrete Institute. A short report of the discussion which followed is also given.

Dovetail corrugated steel sheeting consists of flat steel sheets, crimped into the form of dovetails, and is usually crimped in three depths—viz., No. 1 of $\frac{3}{4}$ in. section, No. 2 of $\frac{1}{2}$ in. section, and No. 3 of $\frac{1}{4}$ in. section. The maximum size of sheets is 3 ft. 9 in. wide—that is, in the direction of the corrugations—and 5 ft. 6 in. in length, or across the corrugations. The sheets vary in gauge from 20 to 28. It is only section No. 1 ($\frac{3}{4}$ in. in depth) that can be crimped to 20 gauge.

These sheets were put on the market about twenty-four years ago, and are used generally for fire-resisting partitions 2 in. to 3 in. thick, fire enclosures to stairs, fire-resisting lift enclosures, mansard and other roofs, strong rooms, linings against damp, theatre balcony fronts, proscenium fronts, and for fire-resisting floors, beams, columns, and even for complete buildings.

It is more usually used in conjunction with plaster, sand, and cement, or concrete and forms in combination, and in reinforced concrete construction, because the steel and the concrete work together in harmony in the same way as reinforced concrete made with concrete and steel bars.

The author's definition of reinforced concrete is as follows: "Concrete reinforced with steel or other reinforcement so that the steel and the concrete will work in harmony, the concrete taking the compression and the steel the tensile stresses, or the steel may be in compression working in harmony with and reinforcing the concrete."

Further, it is to be noted that for the purpose of this definition any material may be termed concrete that sets from a plastic state and hardens so as to work in harmony with the steel in taking up the stresses.

Concentrated Central Load on 5 in. by 2 ft. Area.—The following test shows that dovetail corrugated steel sheeting fulfils this condition.

The construction of test slab is as follows: One 2 ft. length of 2 ft. 6 in. shallow or No. 2 sheeting with 3 in. bearing, ends free; $1\frac{1}{2}$ in. of concrete on top, made of coke breeze and cement, mixed five to one on top; $\frac{1}{2}$ in. sand and cement and four to one underneath; clear span 2 ft.; concrete forty days old.

The total load at collapse of slab was 3,696 lb., which is equivalent to 1,848 lb. per sq. ft. At this load the dovetail sheeting had not broken.

The author has calculated the strain on the coke breeze as 1,492 lb. per sq. in., and of the wrought iron sheeting as 21·62 tons per sq. in. The $\frac{1}{2}$ in. sand and cement on the under side of the sheeting does not figure in the calculation, and the effective depth is taken as 2 in. This result could not have been obtained if the sheeting had not been working in harmony with the concrete.

Properties of Dovetail Corrugated Sheets.—Each dovetail corrugated sheet in length or across the corrugations requires 1 ft. 9 in. of flat sheet, so that a sheet weighs one and three-quarter times a flat sheet. Theoretically if the corrugations are made in proportion for any variation of depth the ratio of crimped sheet to flat sheet will always be the same, but in practice the ½ in. sheets are usually made one and a half to one and five-eighths that of flat sheets, and the No. 3 section about one and a third. This proportion can be still further varied if required, also a section with greater intervals between the dovetails can be used.

For purposes of comparison the following table gives the properties of dovetail corrugated sheets, ordinary corrugated sheets and flat sheets.

Description.	Depth of Sheet.	Gauge.	Section Modulus.	Safe Strength of Sheet at 4 ft. span.	Weight per sq. ft. lbs.
	In.			Lbs. per sq. ft.	
Dovetail Sheet	¾	22	0·1647	108	2·223
	¾	26	0·1062	70	1·4
	½	22	0·1098	73	2·223
	½	26	0·0709	47	1·4
Corrugated Sheet..	¾	16	0·1718	114	2·958
	¾	22	0·0859	57	1·467
Flat Plate..	9/32	3	0·1582	105	11·47

NOTE.—The unit stress is taken as 16,000 lb. per sq. in.

The full theoretical strength of dovetail corrugated sheets can only be obtained by filling in the corrugations with concrete or stiffening the corrugations in some other way. The ordinary corrugated sheets do not require such stiffening.

The ratio of weight of ordinary corrugated sheet is 1·16 of the flat sheet compared with 1·75 of dovetail corrugated sheet.

From the above it will be seen that dovetail corrugated sheets are 50 per cent. heavier and 100 per cent. stronger than ordinary corrugated sheets for same depth and gauge. For sheets of the same strength ordinary corrugated sheets are one-third heavier than dovetail corrugated sheets. A flat steel plate 9/32 in. thick and weighing 11·47 lb. per sq. ft. is of equal strength to ¾ in. 22 gauge dovetail corrugated sheet and 5⅛ times as heavy.

Uses of the Sheets.—The No. 3 dovetail sheeting is used extensively as a damp-course in conjunction with sand and cement. It is a perfect preventive of the damp rising in the walls, and what is more important, makes a material of greater hardness than the bricks, and, in fact, forms an integral part of the wall, there being no chance of squeezing out. It is used also for linings to walls, nailing to wood studs for timber partitions, etc., for laths in place of timber laths for ceilings, forming panellings to ceilings and walls, and backings to cornices and various decorations and enrichments, the plaster being easily worked to the required shape on the dovetail sheeting, which is readily adapted to any form or shape required. It is also used to cover rolled joists, stanchions, etc., as a backing for plaster work.

No. 2 section of shallow sheeting is used for permanent centering for slabs, floors, beams, roofs, columns, and partitions, also outside wall cylinders, etc.

No. 1 section is also used for partitions and walls with or without H and channel irons for railway carriage floors, for stiffer permanent centering, etc.

Partitions.—The sheeting was used for partitions over twenty-three years ago, the thickness being 2 in. to 3 in. These partitions are constructed as follows: Small H iron bars are fixed vertically from 2 ft. to 3 ft. apart, and the spaces between them are filled in with the dovetail sheets, usually of No. 1 section; the dovetails are placed horizontally. This skeleton partition, of great stiffness, is then plastered to the required thickness on both sides. The dovetails form an excellent key to the plaster, the concrete and steel being thus homogeneous; and for the reason stated above this forms a reinforced concrete partition.

Several large partitions have been erected, about 24 ft. by 24 ft., and plastered with sand and cement in the offices of H.M. Government. The dome and barrel ceilings of the National Gallery are other illustrations of this method of construction.

Another type of partition and walls omits the H irons; usually No. 2 or shallow sheeting is used. The sheets are joined together by lapping, to make them the required length, and are placed in position with the dovetails horizontal, and a few ¼ in. round bars are placed vertically on both sides of the sheeting, which is then plastered. This partition is of equal strength to the partition before mentioned, but has less stiffness previous to plastering.

At the commencement of the war the Admiralty required the erection of large buildings in the Falkland Islands for wireless telegraphy. The weather conditions there are very bad; the cold is intense, and terrible storms frequently occur. To meet these conditions it was decided to use dovetail corrugated sheeting for the outside and inside walls and also for the roofs. These were plastered in sand and cement. The outside walls were rendered to a thickness of 4 in.

This system has been largely used for tanks, retaining walls, tunnels, and other linings, and for curved gallery fronts. It has special advantages for curved surfaces and arched work.

Hollow Walls.—For outside walls, hollow walls have been a success. Two walls of skeleton sheeting are erected in either of the aforementioned methods with a space of 2 in. between them and they are tied together at intervals. The outer sides only are plastered to the required thickness. The usual total thickness of these walls is 5½ in.

Floor Slabs.—Floor slabs are usually constructed with No. 2 section sheets, and are lapped in the direction of the corrugations to the required span. The sheets are placed in position and supported at intervals, but without shuttering. Round bars of small section are bent to the required shape, as is usual in reinforced concrete work, and are placed in position. The floor slab is then concreted to the required thickness. For purposes of calculating the strength of the floor slab, the sheeting is taken as the equivalent of reinforcement of ·25 sq. in.

Beams.—For beams the sheeting is made in the form of a trough, the depth of the trough being the depth of the beam below the slab. Flat iron stirrups are placed round the trough and are bolted to it. The top of the stirrup on both sides of the trough is carried up above the trough to within ½ in. of the intended surface of the floor, and at that point the stirrup is bent across the trough and the two ends are bolted together. To form the reinforcement, bent round bars are used and placed in the trough or skeleton beam in the usual manner. The skeleton-beam is erected and supported and is stiffened at intervals without shuttering, and when the reinforcement bars are in position the beam is concreted.

Columns.—For columns the sheeting is formed in the shape of a cylinder or tube with the dovetail sheeting corrugations in the direction of the length of the column. The stirrups are of flat iron, placed at the required distance apart round the cylinder or tube and are bolted to the sheeting.

The skeleton columns thus made have great stiffness. They are placed in position and only require strutting up to prevent movement; they are then concreted from the top. If it is required to have additional longitudinal reinforcement, straight round bars are customarily used and are placed ready for concreting in their positions in the skeleton column. These columns have great simplicity in erection. In all cases after completion the exposed dovetail corrugated sheeting is rendered.

Sound-Proof Qualities.—The peculiar form of corrugation is very helpful in minimising and breaking up the spread of sound. For thin partitions (2 in. and 3 in. thick) this point is of importance, and this applies to reinforced concrete roofs and floors constructed on this system and also to wood floors with dovetail sheets to form a ceiling.

Domes.—Domes are usually constructed in the following manner: Small H irons are bent to the curve of the dome in vertical section, fixed radiating and connected at the top to a circular plate or channel iron ring of suitable radius. Dovetail corrugated sheeting is fixed between the H irons with the dovetails horizontal, and when necessary round bars, resting on the H irons, encircle the dome. The outside is then concreted to the required thickness and the dome is rendered on the inside. No centering is required, but only strutting up and the necessary stiffening while work is going on.

Roofs.—The advantages of the dovetail corrugated sheets for roofing are many. The roof is easily erected ; a minimum of concrete (from ½ in.) can be placed on top of the sheets, making a 1 in. slab, if the under side is not rendered or only the dovetails are filled up ; if rendered it will amount to not more than 1¼ in. thick.

Air Trunks.—Large ventilating air trunks have been constructed with H irons and dovetail corrugated sheets. The H irons are bent to the shape of the trunk, which is completed by rendering on both sides.

Railway Carriage Floors.—One important development in the use of dovetail corrugated steel sheeting which has been made in recent years is for railway carriage floors, 22 gauge, ¾ in. in depth being used. The span varies, the maximum being about 3 ft. 9 in. The sheets, which are galvanised, are put on and bolted to the frames of the railway carriages and a special composition is put on the top of the sheets, which are covered ½ in. in depth. Only the under side of the sheets is treated or protected by painting.

Shipbuilding.—It seems that there should be a great opening for this material in shipbuilding. For the skin of the vessel the sheets can be joined together by lapping or welding, and be made perfectly water-tight. The strength can be increased by putting bars across or at right angles to the corrugations of the sheets, so as to form a square or rectangle that will take stresses in both directions. For a square slab supported on four sides the moment is $\frac{WL}{24}$ instead of $\frac{WL}{8}$—that is to say, three times the strength of one supported on two sides only. This is the French rule, and the author considers it correct. Continuity in both directions will still further increase the strength of the sheeting. Concrete need only be put on the outside for the thickness necessary for the calculated stresses.

For ¾ in. sheeting, 22 gauge, no concrete is needed on the inside, as the safe strength previously mentioned for 4 ft. spans supported on two sides is 108 lb. per sq. ft. It seems, therefore, that the skin of a reinforced concrete ship constructed on this method would be lighter than any other. For bulkheads this material seems invaluable, and also for decking and deck buildings.

The deck buildings could be constructed after the vessel is afloat, and so could some of the bulkheads.

Aeroplanes.—Ordinary corrugated sheeting is now being used for aeroplanes, presumably for the larger types. Dovetail corrugated sheeting can be used for the same purpose, with the advantage that for equal weights the dovetail sheeting is stronger than ordinary corrugated sheets in the ratio of 4 to 3, which would be a great advantage.

Mizen Head Bridge.—The Mizen Head bridge (of which the author gave various illustrations) was erected to provide access to Cloghan Island at Mizen Head, the extreme south-west point of Ireland, on which the Commissioners of Irish Lights have built a fog-signal station.

The island is separated from the mainland by an inlet to the sea, and the site chosen for the bridge necessitated a span of 172 ft. at a level of 150 above the sea. Designs were called for, and Mr. C. W. Scott, Engineer to the Commissioners, chose the design sent in by the author for a bridge in reinforced concrete The concrete bridge was preferred to the steel bridge, for which several cheaper designs were sent, as the maintenance of the latter would be so costly and the life so short in such an exposed position, where the bridge is often smothered with spray, and where wet fogs are prevalent.

The contract was placed in the hands of Messrs. Alfred Thorne & Sons, of Westminster. The bridge is 172 ft. long in one span, and is of the through arch type. The ribs are parabolic curves with a versed sine of 30 ft., and are of rectangular section 3 ft. by 1 ft. at the springing and 1 ft. 6 in. by 1 ft. at the crown. The ribs are parallel in the centre portion at 5 ft. 6 in. centres, but where the footway comes through at the quarter span they splay out, being 15 ft. centres at the abutments, and are connected by wind-bracings. This is to give stability under pressure, as the bridge is so narrow.

The footway is 4 ft. 6 in. wide between the horizontal beams, and is 5 in. thick at the centre, including the granolithic surface ; the beams are 15 in. by 9 in., and the reinforcement is made continuous from end to end by rigid connections and is anchored to the rock on either side to stiffen the bridge under unequal loading.

The trestles and wind-bracings are 9 in. by 9 in. section, and the hangers 9 in. by 6 in. The handrail is of reinforced concrete with 4 in. octagonal rails, and posts 9 in. by 6 in. to 6 in. by 6 in. The rock on either side is benched out to receive the concrete abutments in which the ribs are bedded.

The novel feature of this bridge, apart from its great span (which is believed to be the greatest yet attempted in the British Isles) and its height above water, is that it was possible to erect without centering, thus effecting a great saving in cost.

The ribs were made in four portions, all on shore, and then built out from the abutments. They were in the form of a trough open at the top and connected with stirrups to prevent spreading.

The trough consisted of dovetail corrugated sheets placed with the dovetails in the direction of the depth of the trough for the sides, and across the trough at the bottom.

Mr. E. Fiander Etchells said that on the question of the bending moment, the author stated: "In the accepted formula of $\frac{WL}{8}$ for two span continuous beam for the stress over the support, this makes the beam no stronger than a beam of one span supported at the ends." The author then went on to say that this did not accord to reason, because in the two-span continuous beam there were two resistances, one at the centre and one at the haunch, while for the supported span there was only one resistance. He would like to point out that that argument was not so sound as might be wished. In fact, it was a *non sequitur.* It might be that the formula given provided a strong beam, but the fallacy of the argument was in saying that two resistances were always and invariably stronger than one resistance. It depended very much upon circumstances. If there were two rivets side by side they would certainly give double the strength of one, unless one of the rivets was a bad one. If, however, they took the analogy of a chain, it could not be said that a chain with twenty links had double the strength of a chain with only ten links. As a matter of fact, there were probably twenty chances of failure against ten. With a chain of twenty links they had double the resistance but not double the strength, and the same applied to beams. With a long chain of beams in series two resistances were not necessarily stronger than one, and it would not do to build on that particular argument with regard to other structures. The Mizen Head bridge was bold in design, and although he was rather timorous about expressing an opinion upon any matter artistic, yet that bridge somehow appealed to him and pleased him. The roof of the Brighton Pier concert hall was also interesting, and he had had an opportunity of inspecting it rather more closely than usual, having been swung from one pier to the other and seen some of the piles.

Mr. W. A. Brown, speaking with regard to the use of dovetailed sheeting for damp courses, asked how the grooves on the under side were filled in, or were they sheets just laid on the top of the brick? That raised the question of the deterioration of the sheeting, because if it was not protected it was likely to rust on the under side. Another point to be emphasised was that lime plaster could not be used for partitions made of this sheeting, because the lime naturally would eat the reinforcement away He used some of these partitions many years ago and had to be careful to use cement and sand for the rendering before putting the second coat on. Whilst these made strong partitions it was necessary practically to knock the whole partition down if it was wanted to cut an opening. That was one objection he had to it himself. With regard to the calculations for reinforcement, were these made upon the depth of the reinforcement? He gathered from the tests in the paper that they were measured from the centre of the dovetail. If these sheets were used for aeroplane construction, as suggested, it appeared to him that there would be considerably more wind resistance unless the dovetails were filled in, although that would make them heavier.

Mr. Etchells said that the difficulty as to aeroplanes mentioned by the last speaker was overcome by sewing canvas on both sides over the corrugations. In this way the Steel Wing Co. was able to produce wings for aeroplanes having greater strength than wood and, strangely enough, lighter than wood and with an air resistance no greater than wood, the explanation being that the canvas covered the whole surface so that there were no corners to increase the head resistance.

Mr. E. L. Hall referred to the statement in the paper that each dovetail corrugated sheet in length or across the corrugations requires 1 ft. 9 in. of flat sheet. Was that per ft. length across the sheet? Referring to the value of this corrugated sheeting as reinforcement, the author had stated that it was taken as the equivalent of reinforcement of ·25 sq. in. Was that per ft. of its width?

THE LECTURER'S REPLY.

Mr Noel Ridley, replying to the discussion, said he could not quite follow the point Mr. Etchells made with regard to the chain. A chain of a certain length was not necessarily double the strength of a chain half the length; given the same conditions in both cases the strength would be the same, but he did not see why Mr. Etchells objected to the argument in the paper about there being two resistances in the case of two-span continuous beams. With a span simply supported at the ends there was a resistance in the middle, and the moment of that was $\frac{WL}{8}$. When that beam was carried as one beam over two spans there was a contra-resistance over the haunch which was, so to speak, fighting against the resistance in the centre. It must be admitted that that shortened the span of that beam to a certain extent. That shortening must increase the strength of the supported portion because the span was less, and then there was the cantilever portion, which had a weight, for distributed load, at the end of half the supported beam and a distributed load for the rest of the cantilever, so that at once they had the two resistances fighting against each other. Therefore, it seemed unreasonable that, having these two resistances, the beam should be no stronger than the supported beam under the accepted formula of $\frac{WL}{8}$. It seemed to him an impossibility, and certainly his own tests—and he believed there were many other tests—showed that there was something wrong in the formulæ in the textbooks. Although these might be due to some active mathematician of the age, they did not appeal to him as correct. Claxton Fidler gave instances and mentioned a great number of authorities, mostly Continental, but he did not explain or give any information as to the theory of these authorities. Fidler then gave one of his own, and said that, although it did not really properly demonstrate it, yet it was an illustration. Fidler took a beam 120 ft. long, supported at each end, and he calculated the moment and the deflection. Then he took the same beam and put a column in the centre without any supports at the ends, and calculated that. Of course he got the same moment of resistance, one as a cantilever and one as a supported beam. He then calculated the deflection in each case, after which he put a column under the ends and gradually lifted them up until he got to the horizontal. In doing that, however, he was transferring the strength, and instead of being wholly a cantilever he made a portion a supported beam and the rest a cantilever. It seemed to him, therefore, that the whole argument was vitiated at once. There was another authority, Binden Stoney, who was a great authority on girder work. He got his point of contraflexure by a test on timber, in order to find out what was the weight on the two end supports and the support in the centre, but apparently his result was according to the formula. Whether that was the origin of the formula in the textbooks, he was not sure, but he took it that it was. When the formula which he had given was compared with the accepted formula, the weight on the centre of the span was only a variation of 6½ per cent., and it required a very fine test indeed to be quite sure of the load on the centre of the column, but when the two formulæ were compared on the point of contraflexure, there was a much bigger difference. Under the accepted formula, with a point of contraflexure from the hinge of 15 ft., this would be 10½ ft. under his formula. Thus there was a big difference on the point of contraflexure and a small difference on the point of loading of the columns and supports. The matter could be argued to a considerable extent, but he would leave it there for the moment and deal with the other points raised in the discussion.

In reply to Mr. Brown on the question of damp courses, the sheet was laid on to a bed of sand and cement, and a portion of sand and cement was put on the top, and thus there was no chance of rusting. As to the effective depth of the sheeting, this was usually half the depth of the sheeting, but in certain cases it could be taken to the full depth. The area of ·25 as the equivalent of reinforcement was less than the area of the sheeting, but it was a workable one, because it was not always possible to be exact as to the area that could be taken. The lap was 2 in. to 3 in., and even with a slight distortion there was no chance of slipping, especially in the lighter gauges, nor for the heavier gauges.

Regarding the two questions raised by Mr. Hall, Mr. Ridley said the answer to both was in the affirmative.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

As a Man Liveth.

Published by Associated Metal Lath Manufacturers, 901 Swetland Building, Cleveland, Ohio. 31 pp. Price $1.00.

The housing problem is of such importance at the present time that any publication which contains suggestions and examples of cheap and efficient construction for domestic work must be welcomed, and due consideration should be paid to the ideas contained therein. "As a man liveth so shall he work" is a true saying, and the introduction to this volume puts forward a very clear statement as to the need of providing sufficient and suitable homes for the workers if they are to become permanent dwellers in the vicinity of those large industrial centres where labour is urgently required. The volume then deals with the essential principles of metal, lath and stucco construction, wherein the advantages of economy in construction, maintenance and heating, together with the questions of adaptability, permanence and fire-resistance, are fully discussed.

Many examples of buildings erected on this system are described and illustrated, and the appearance in several of these is quite pleasing. The method of construction is illustrated in *Fig.* 1, where it will be seen that the lathing is attached to wooden studs on both sides to give a hollow wall. The fixing is accomplished with staples driven into the studs and furring strips are provided to permit of efficient key at all points. The external lathing is stuccoed on the outer face and plastered on the back to bring the lathing

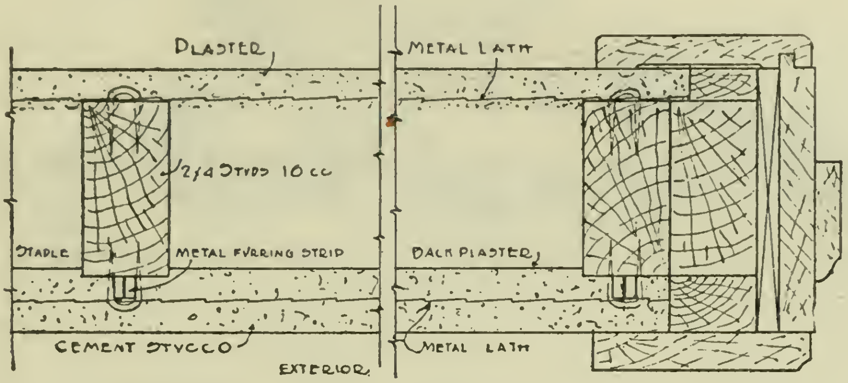


Fig 1. Section through exterior door opening.

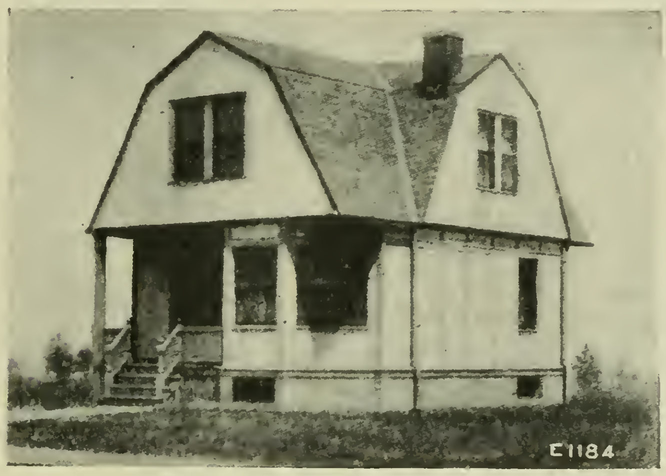


Fig. 2. Gambrel roof type.

in the centre of the thickness, and the internal lathing is plastered on the room side only. This lathing has been found to be in perfect condition after it has been in position for 27 years.

The illustrations in *Figs.* 2 and 3 are taken from the book, and show the satisfactory appearance that can be obtained with this construction..

Specifications for stucco work are given, and also the results of several tests that were made to determine the fire-resistance of panels formed with metal lathing and stucco, and these results certainly indicate desirable qualities.

The book is well arranged, and although it is published for advertising purposes it is worth obtaining, and the methods suggested might be considered in connection with some of the cottages urgently required in this country, if the existing arbitrary by-laws could be amended to permit of their adoption.

B.R.C. Reinforcements.

Manchester: The British Reinforced Concrete Engineering Co., Ltd. 172 pp.

This is an interesting booklet which contains notes and descriptions of the B.R.C. specialities, and the matter is well arranged in a manner which enables the architect or engineer to refer quickly to any desired portion of the subject. Useful features of the book are the tables of safe loads which have been included for various types of members, and the architect or engineer when preparing sketch schemes can easily ascertain the necessary size and reinforcement required to carry the calculated load in the case of slabs, beams or columns.

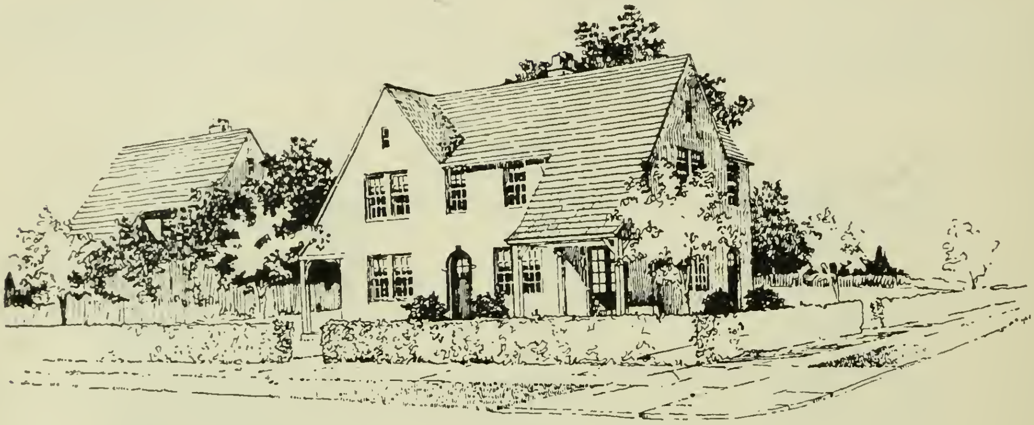
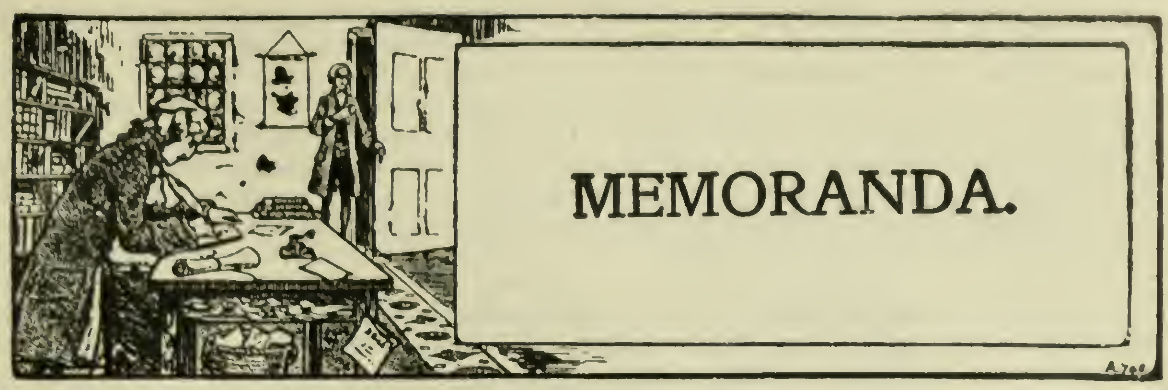


Fig. 3. Two six-room Dwellings.

Tables are also given for foundations and piles, and useful notes are given in connection with retaining walls, bunkers and silos, bridges and similar features, while reinforced brickwork and the properties of steel wire and bars are also treated.

Several pages are devoted to concrete, and the Report of the Joint Committee on Reinforced Concrete is included at theend of the book for reference.

The booklet is nicely bound, and will be appreciated by users of this material on account of the useful matter which is contained therein.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

British Scientific Products Exhibition, 1919.—The King has graciously consented to act as President of the British Scientific Products Exhibition, 1919, which will be held at the Central Hall, Westminster, during the month of July. The President of the Exhibition is the Marquess of Crewe, K.G., and Professor R. A. Gregory is Chairman of the Organising Committee.

The British Science Guild has been encouraged to organise this Exhibition by the success which attended that held at King's College last summer and the more recent Exhibition at Manchester. Now that many inventions can be shown which could not be put before the public during the war, there is every prospect that this year's Exhibition will be even more successful than its predecessors. The objects of the Exhibition will be to illustrate recent progress in British science and invention and to help the establishment and development of new British industries. Such an Exhibition will enable new appliances and devices to be displayed before a large public, and will provide progressive manufacturers with an opportunity of examining inventions likely to be of service to them, thus serving as a kind of clearing house for inventors and manufacturers, as well as illustrating developments in science and industry.

The Exhibition will include Sections dealing with Chemistry, Metallurgy, Physics, Agriculture and Foods, Mechanical and Electrical Engineering, Education, Paper, Illustration and Typography, Medicine and Surgery, Fuels, Aircraft and Textiles. Firms desirous of exhibiting are invited to communicate with the Organising Secretary, Mr. F. S. Spiers, 82 Victoria Street, London, S.W.1.

The Institution of Civil Engineers, at its meeting held on January 28th, elected upon its Roll of distinguished Honorary Members: Marshal Foch, O.M., Field-Marshal Sir Douglas Haig, K.T., Admiral Viscount Jellicoe of Scapa, G.C.B., O.M.

The Reconstruction of Bridges Destroyed during the War.—The bridges which have been destroyed during the war are of two kinds; those made of metal can be repaired with comparative ease, but those of masonry will require a much longer time, as skilled masons are short, and stone dressing is necessarily slow work. The materials used for concrete, on the contrary, are easily obtained, and any desired shapes can be made without difficulty. One firm in France has already commenced supplying arches and other specially shaped concrete blocks to replace the damaged parts of bridges, etc. Another useful suggestion is to supply a series of arch units, which are placed side by side to form the larger arch, each unit being sufficiently small to be handled readily by ordinary contractor's plant and slung into position. Other blocks may be moulded on or quite near to the site. By such means it should be possible to repair the most seriously damaged bridges in a rapid and simple manner.—*Le Génie Civil*, 1919.

Concrete Houses.—Messrs. Harnis and Small have recently built in the war-devastated areas of France some cottages of concrete moulded in a novel manner. The mould or form is built in sections occupying a space equal to the thickness of the wall of the building. Each section is small enough to be moved by one man, and it is arranged to fit accurately to its neighbours. The inside of the mould is machined, so as to prevent the joints showing unduly. Special sections are provided for angles, cornices, etc. The sections are held in place by ties which remain in the concrete when the forms have been removed. Special angle pieces are filled to the outside of the moulds to facilitate the dismantling. The usual procedure is as follows :—Two rows of plates are placed on the ground at a distance of 6 in. apart ; others are fixed above them so as to form the external wall of the mould up to the first floor. Behind the wall thus formed are placed ⅜ round steel bars to act as reinforcement ; they are fastened to the ties previously mentioned. The mould for the chimney flues is then placed in position, then those of the doors, windows and the staircase. The inside part of the mould is then fitted and the two walls fixed by means of the ties. The floor is made separately and is placed in position, and the erection of the moulds is then continued to the second floor, the work being assisted by means of supports. The erection of the complete form requires about eight hours. The concrete must be sufficiently fluid to flow well. A satisfactory mixture consists of one measure of cement, two of gravel up to ¼ in., three of fine sand. A little clay is added to the water used. The proportion of water is 120—175 per cent. as compared with the 40 per cent. generally used. This fluid concrete is poured into the form work without any special precautions, about six to eight hours being required for placing the whole of the concrete for a double stoned cottage of five rooms.—*Le Génie Civil*, 1918.

Concrete in Japan.—A correspondent, writing to *Concrete*, U.S.A., says as follows : —" Beyond the electric light, which penetrates to every part of Japan, and has been adopted because of the former disastrous fires in the wood-and-paper villages, one rarely finds anything modern in the interior, The writer was, therefore, very much surprised to come upon a concrete block establishment in a remote section that had never before even seen an automobile. It was on the shores of Lake Kawaguchi, some 90 miles from Tokyo, and while the method of manufacture was crude, the blocks solid and made in wooden moulds by native women, nevertheless they were *bona fide* concrete blocks.

" At this isolated point it is necessary to transport material either by the two-wheeled coolie carts or horse-drawn vehicles over many miles of rough and somewhat hilly roads. But the Japanese are not only quick to adopt new ideas, but are alert and adaptable, and with the great impetus to manufacturing since the war began, foreign methods are coming more and more into use, concrete building among them.

" Cement-faced buildings there are in great number, but the true concrete building, whether of hollow block or reinforced, has yet to make its appearance. With the present rapid progress in building methods, however, it is certain that this substantial and economical type of structure will appeal to the Japanese builder.

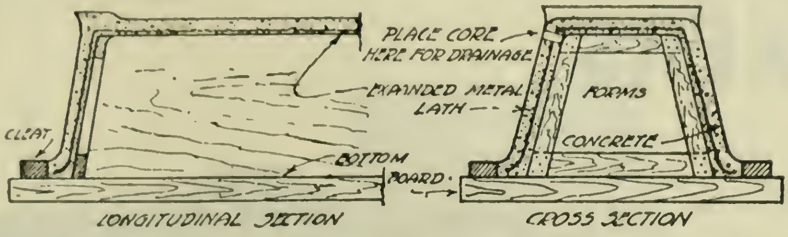
" The fire-resisting ' godown,' or storage vault, has long been a feature of Japan, and may be found everywhere. This is a frame building with cement face and is used for storage of valuables by the well-to-do merchants. Dwelling-houses and shops are invariably made of light wood, with paper panels for windows, and are obviously inflammable, so that when a fire starts in a village and there is a high wind, usually the entire community is wiped out, and the godowns stand up as gaunt and smoke-grimed sentinels on guard over the smouldering ruins. There should be an excellent field in Japan for the concrete block godown, because of its low cost and facility of construction.

" Progress made by the concrete block is confined largely to walls, and these are seen in great number, for the native Japanese desire for privacy inspires him to shut out the public gaze by either a high board fence or a stone or concrete wall. Concrete roads are having their introduction by the surfacing of some of the metropolitan bridges and short sections of the more heavily travelled streets."

Concrete Bricks.—The use of concrete bricks is being advocated in connection with the building of the fire-resisting compartments in large switchboard work. From inquiries made, it appears that the material most desirable is concrete brick of standard brick size, made in a very simple machine out of one part cement mixed with one and a half parts of sand and two of gravel.

It is found that three men can easily turn, mix, and turn out about 2,000 bricks a day, which are cured by about twelve hours' treatment in a steam bath. It is found by experience that a given structure can be built more quickly and cheaply at present from such concrete brick than from the moulded cement, making a strong and fire-resisting structure at a cost materially below that of brickwork. The bricks can be placed in position readily and quickly by ordinary labour.

A Concrete Flower Box.—The following is a method for making a concrete flower box according to a writer in *Concrete*, U.S.A. :—Place a sheet of expanded metal over a wooden form, then a coat of about ¾ in. concrete. When this has set a stucco coat may be applied with pleasing results. The following diagrams give the details of construction.



Concrete Smokestack.—A new smokestack was recently completed for the Anaconda Copper Mining Company. The new stack is 585 ft. 1½ in. high. Its base of reinforced concrete is 86 ft. outside diameter and 75·4 ft. inside. At the top the inside diameter is 60 ft. It weighs about 34,000 tons. In comparison with this stack, the Tacoma smelter stack is 572 ft. 10½ in. high ; one in Japan 570 ft. ; and that at Great Falls, Mont., 510ft.

Cement-Covered Cables.—It was reported recently that a large electric light and power supply undertaking rendered its cable fire-resisting with cement and asbestos. It has been found that the cement covering is unaffected by a burn-out in a manhole ; whereas the asbestos covering sometimes proves ineffectual.

Cables have failed in manholes in which these two types of protection were present, and on examination the cable covered with asbestos has proved to have been badly burned, while the cement-covered cable has remained practically uninjured. The burn-outs mentioned were caused by a short circuit of 500,000 k.w's. on a 6-in. cable.

The company in question states that rendering fire resisting with cement is as cheap as the asbestos method, and in some instances proves even more economical. When used for 4-in. cables it costs from 8d. to 10d. per lin. ft. The covering is made of cement mixed with good sharp sand in the proportion of one to three, and it is applied and wrapped in place by means of 3-in. strips of cheesecloth, the coating being applied spirally.

When it is necessary to remove the cement coating it can be easily chipped off by blows from a light chipping hammer. The labour cost is rather higher than when installing asbestos cables, but this can be offset by the difference in the cost of the two materials. A number of transatlantic power undertakings are adopting, or about to adopt, this method of covering for open runs of cable.

New Industry in South Africa.—A Doornfontein firm—having started by making concrete tiles—succeeded, after many experiments, in turning out what appears a good-class article to take the place of corrugated iron. This tile is made of a composition of concrete and asbestos-waste, which is placed in great tubs, beaten by long-flanged rollers similar to those used in bread-making, and then laid in moulds that turn out a tile a foot square. The tiles are then covered with canvas mats, subjected to a pressure of 60 lb. to the sq. in., left to dry partially for 24 hours, and then plunged into water for some hours longer. They then undergo a further drying process for almost a fortnight, when they are ready for sale, though the makers allege they improve as they get older.

The cost per square of 100 ft. is considerably less than that of corrugated iron or the ordinary clay tile, on account, mainly, of the much lighter framework required.

Reinforced Concrete Bridge at Malmo, Sweden.—It is reported in the *Teknisk Tidsknift* of December 18th that a reinforced concrete viaduct has recently been completed at Malmo. The viaduct is 660 ft. long and has six spans, carrying a 30 ft. wide roadway, with a footpath on either side 11 ft. wide.

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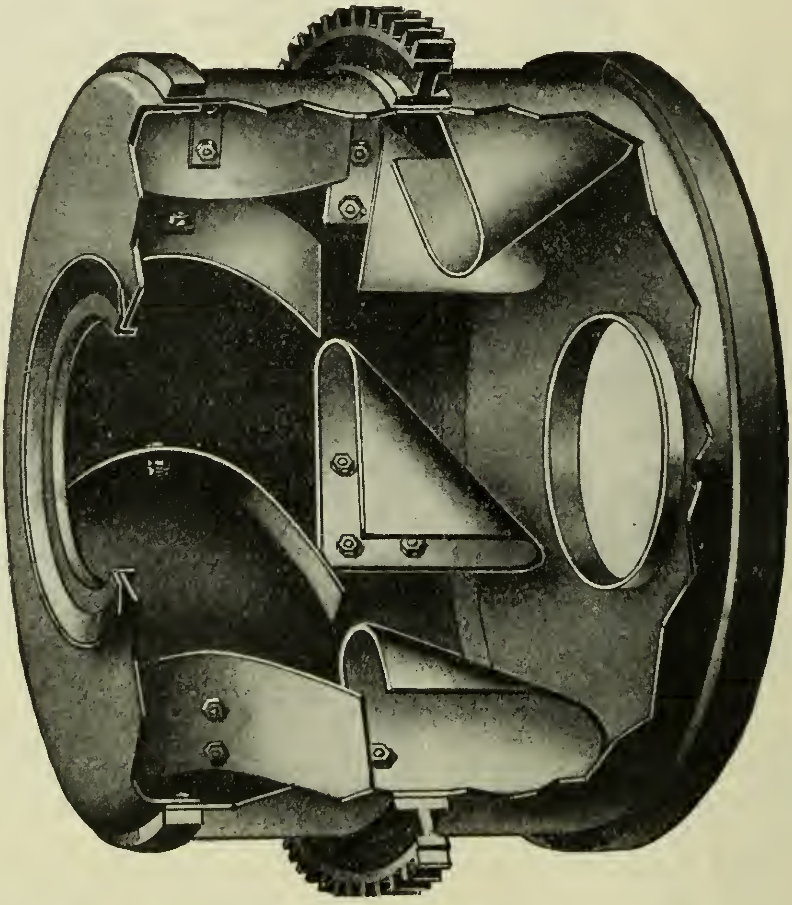

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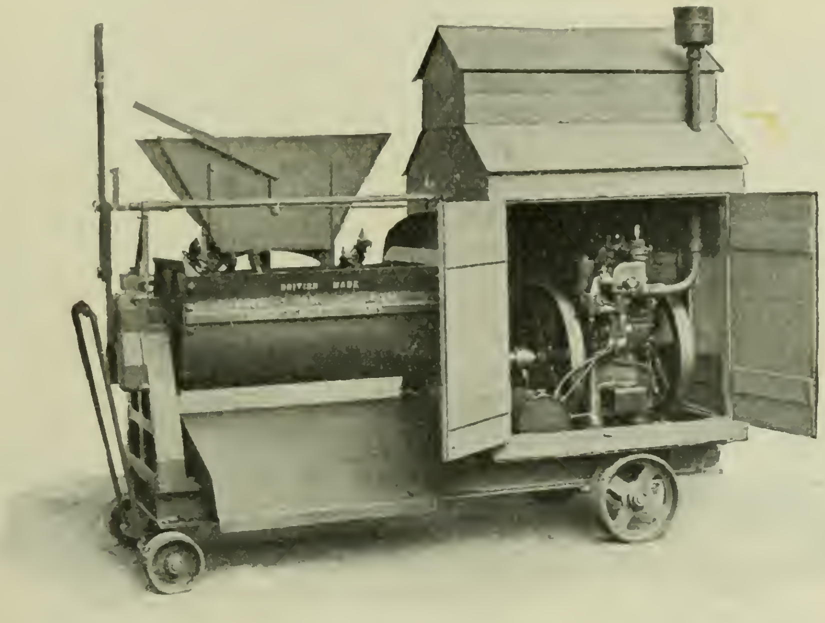
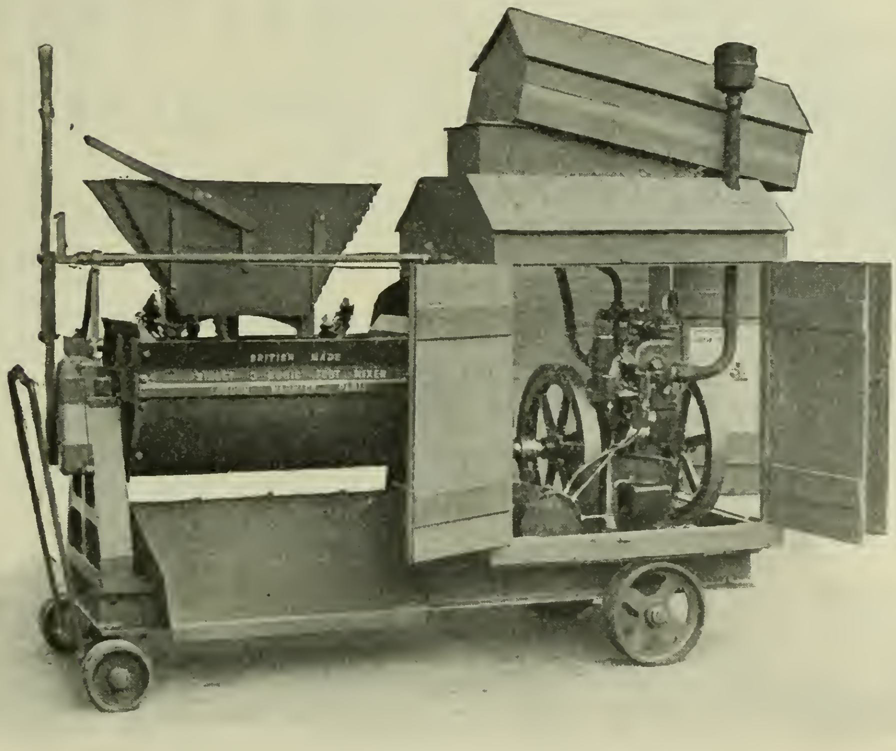
Catalogues in course of preparation.

TRADE NOTES.

The Chain Spade Concrete Mixer.—Messrs. Winget, Ltd., have just issued a catalogue describing and illustrating their perfected Chain Spade Mixer. It is claimed for this mixer that whilst absolutely simple in construction, it ensures in an efficient manner the absolute distribution of the cement with the smallest particle of aggregate, thus reducing the danger of voids and other fruitful sources of unsound concrete. The working of the mixer is very simple. Aggregate and cement are fed into the fixed measuring hopper, and thence by one movement of the lever, which raises a sliding door for the purpose, they are emptied into the mixing trough. Here they come into immediate contact with the revolving chain spades, and are quickly and thoroughly mixed.





The mixing is entirely under the control and within sight of the operator throughout.

It is also worth noting that the mixing is practically continuous, as we understand the succeeding batch can be admitted immediately its predecessor is emptied. If required for tar, macadam, or asphalte work, the trough can be fitted with a steam coil for heating purposes.

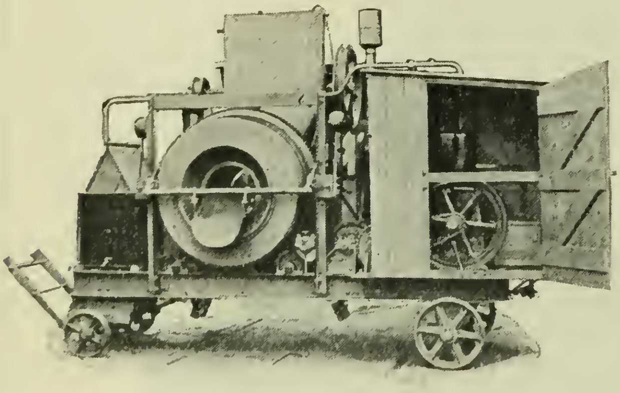
The Chain Spade Mixers are made in three sizes—viz., 3 cu. ft., 6 cu. ft., and ½ cu. yd. capacity.

A fully descriptive illustrated catalogue can be obtained from Messrs. Winget, Ltd., 25 Victoria Street, S.W.1.

NEW PUBLICATIONS.

How to Form a Company. By Herbert W. Jordan (Twelfth Edition). 1s. 4d., post free. Published by Jordan & Sons, Ltd., 116 and 117, Chancery Lane, W.C 2.

Foreign Trade Supplement of "The New York Evening Post."—*The New York Evening Post* announce that, commencing from April next, they will publish a monthly supplement entitled the "Foreign Trade Review," dealing with the overseas markets from an American point of view, and the Editor will gladly welcome, in this connection, trade news, contributions of commercial interest, and particularly on any subject of Anglo-American interest.



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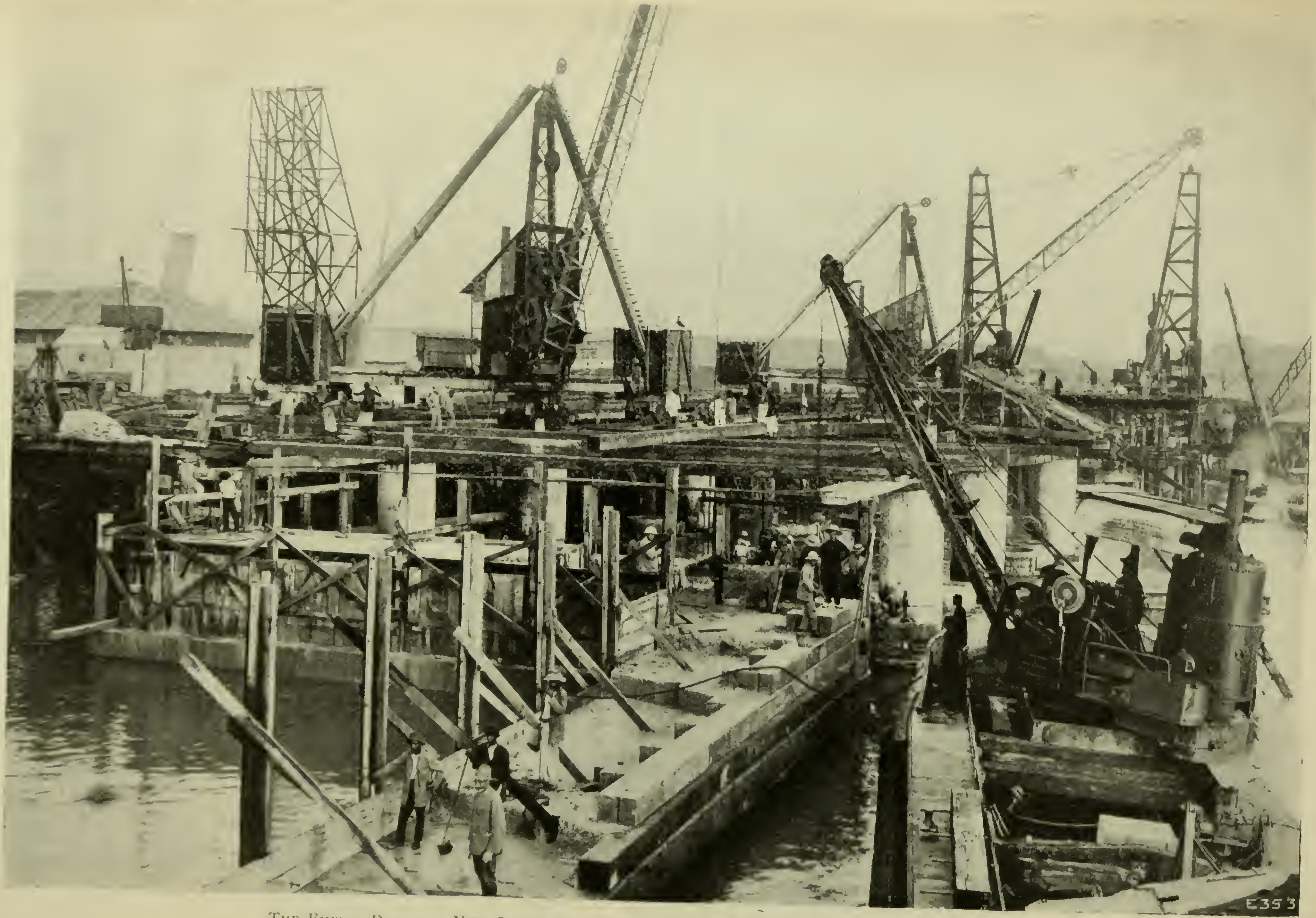


The Empire Dock and New Quays, Singapore. Showing Reconstruction of Main Wharf.
(*For description see page 167.*)

164 ✓—

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 4. LONDON, APRIL, 1919.

EDITORIAL NOTES.

THE HOUSING QUESTION.

GENERALLY.

THE chief problem of the reconstruction programme, in which the national interest is now centred, is that of housing, and despite the large amount of discussion which has taken place it is still doubtful if the real magnitude of the task has yet been grasped by those in authority.

The need for a very large number of houses immediately is very pressing, and only those who have been compelled to seek new homes can realise the acute situation that prevails.

Competitions are very helpful if they are productive of new ideas, but so far the conditions have either been ignored or have contained no reference to the essential problem before us, which is that of building efficiently, cheaply, and with rapidity by using up materials which are actually available.

MATERIALS.

The apparently necessary officialism that accompanies all schemes carried out by public bodies is bound to result in considerable delay in the commencement, but we feel that advantage could at least be taken of this to proceed with the preparation of some of the materials which will be required in the construction of the houses to prevent the present shortage from becoming more acute. Orders have apparently been placed for bricks and other articles, but it is quite impossible to produce even a large proportion of the materials required unless some special efforts are made to build up a tremendous reserve of all available units. Why should not the manufacture of concrete blocks and other units be proceeded with in order to meet the demand that is bound to be made for this material? The total output of the brickyards of this country is quite inadequate for the needs of the new housing programme, and it is quite certain that industrial buildings will require some proportion of the output unless trade is to be hampered to the detriment of the community generally.

WALLS.

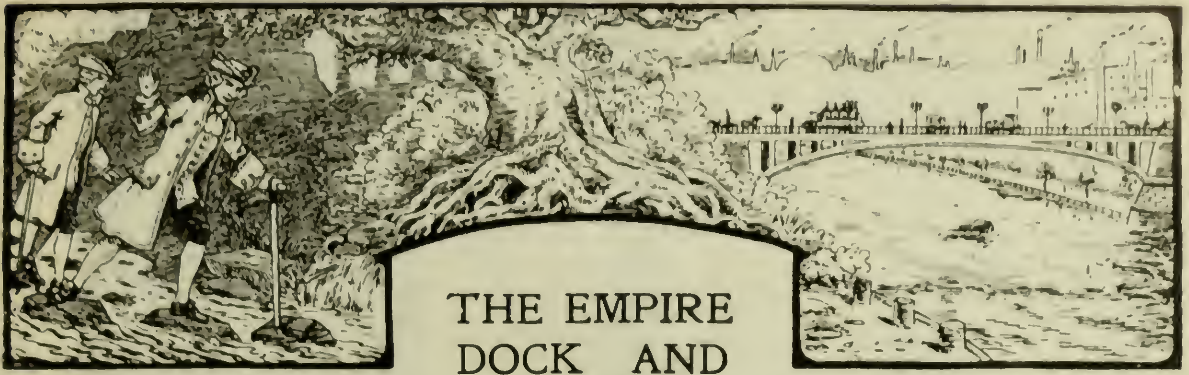
Sufficient attention has not been paid to the possibilities of using concrete blocks and other methods of construction for the walls, and yet this is a most important point. A sample house has been erected, according to the daily press, in which the walls, floors, and other parts of the building have been constructed with material composed chiefly of sawdust. This may be ingenious and novel, but as the amount of sawdust is extremely limited, the method is not likely to be of much use in providing a solution of the problem. The best type of wall is undoubtedly that constructed in two thicknesses to give a cavity 1½ in. or 2 in.

wide, because by this method the maximum weathertightness is assured, and the trouble of condensation is reduced to a minimum. The use of this method of construction permits the adoption of a wider range of materials than would otherwise be possible, and it should form the basis on which the suitability of any material is to be judged. Brickwork 9 in. thick is not weathertight if built solid, but when divided into two thicknesses with a cavity, a perfectly weathertight wall is obtained. The mere fact that a 9 in. solid wall is not ideal does not mean that bricks are to be condemned for walling purposes, and no one would attempt to put forward arguments against their use, but it does mean that they should be employed to the best advantage. In spite of this apparently simple and obvious reasoning, however, the use of concrete for walling is being continually condemned by the inexperienced, because some instances can be put forward where 9 in. walls built in one thickness have been found unsatisfactory. The difficulty that arises with a 9 in. wall in concrete is that the necessary weathertightness can only be obtained by the use of an impervious mixture, and it follows that if the body of the material is of a similar nature then condensation must result on the inner face. We have yet to see the house or cottage that has been constructed with concrete blocks on the continuous cavity principle, which is not satisfactory, both as regards weather resistance and condensation. This method also has the advantage of allowing the use of inferior and porous aggregate for the inner blocks ; thus economy is effected by reserving the more valuable aggregate for the outer blocks only. There are enormous quantities of clinker produced all over the country, which could be utilised for the internal portions of the walls with perfectly satisfactory results, as has been proved by the many examples executed under the guidance of expert concrete advocates, and yet the majority of this clinker is looked upon as practically worthless material.

It is only by using such available sources of material that the necessary rapid progress is possible in the erection of the half a million cottages and houses that are urgently required. The manufacture of standard blocks could be proceeded with immediately on a large scale, and considerable employment could in this way be given to the many workers who are now disengaged.

In view of the urgent needs of the problem it is also essential that all possible methods be considered, and, as an example, mention may be made of the frame buildings which are so extensively used in America. These could be looked upon to a certain extent as a temporary measure to cope with the abnormal demand for houses, as they could be so speedily erected that a large number could be available in a short time. This method consists of a framework, which is covered with expanded metal on both sides, and the whole is then covered with stucco on the outside and plaster internally. The external lathing in the best work is covered with stucco on both sides, and thus the metal is protected against corrosion, and will last for many years. Brickwork could possibly be adopted for the ground-floor work where damage might be likely to occur, and the first floor could be framed, thus combining lightness with economy in bricks, which are bound to be scarce. In lieu of timber studding concrete members could be used for the supports to the lathing, and thus a permanent structure would result.

There are many such suggestions that could be made, but it should be sufficient to give some indications of the procedure that should be adopted to deal with a question which has become an acute matter, demanding instant and serious attention as affecting the interests of the whole community.



THE EMPIRE DOCK AND NEW QUAYS, SINGAPORE.

From the following notes it will be seen that both concrete and reinforced concrete were used to a considerable extent in the development and extensions of the Port of Singapore.—ED.

THE works illustrated by the accompanying photographs were completed and finally opened in May, 1917.

The development of the maritime trade of Singapore has been phenomenal, for it was only in 1868 that the first dock, known as the Victoria Dock, was constructed. In 1879 the Albert Dock was finished, and this was followed in 1913 by the King's Dock.

Increasing trade, however, soon caused a demand for further shipping facilities, and in January, 1908, the works here shown were commenced.

The " Empire " Dock covers an area of 24½ acres. Its depth is 30 ft., but here again arrangements have been made to give a depth of 33 ft. if such depth should in the future be found to be desirable.

The sides of the dock are designed to give 3,532 ft. of deep water quayage and 1,900 ft. of stepped quay for lighters, etc.

Figs. 1 and 2 give a panoramic view of the Empire Dock and the entrance to it. The main walls are of mass concrete, faced above low water with moulded concrete ashlar, finished off with a granite coping The north side of the dock has a pitched slope in lieu of wall, the slope being formed above low water of stepped concrete pitching. On the further side of the entrance, as shown in the illustration, the wall was constructed of concrete blockwork, the superstructure being of mass concrete faced with moulded concrete ashlar, and the near side of the entrance was formed of iron cylinders filled with concrete, with steelwork superstructure, and a rubble bank was formed to retain the filling. This side was then finished off by a dwarf wall of concrete blockwork.

Fig. 3 shows one side of the Empire Dock and the complete wharf. The wall throughout has been formed on the solid shale, and in one place it was found necessary to go down to a depth of 83 ft. below the coping level.

The frontispiece shows the reconstruction of the main wharf facing the harbour at the junction between a blockwork wall and a reinforced concrete

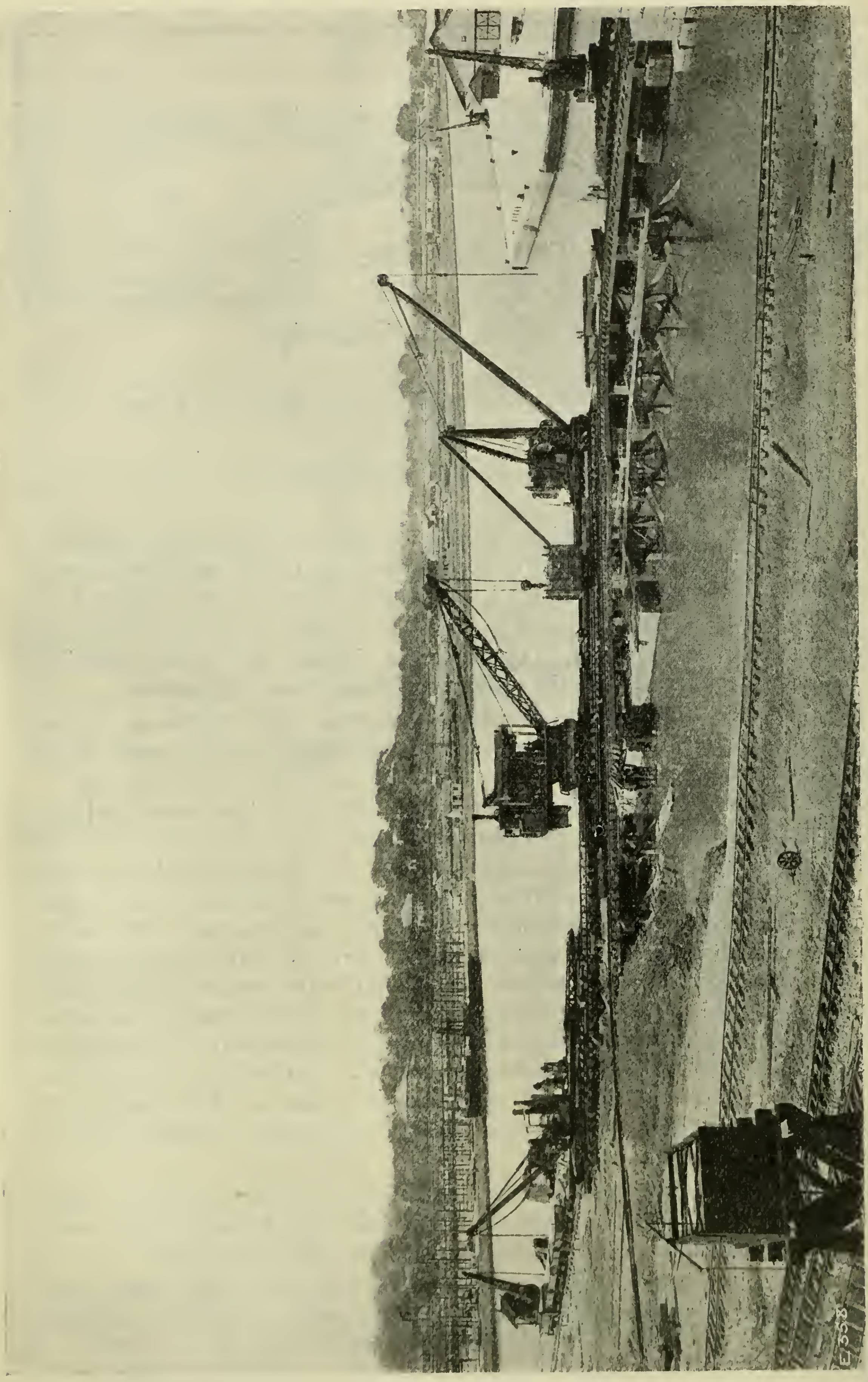


Fig. 1. A Panoramic View of the Empire Dock.
THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

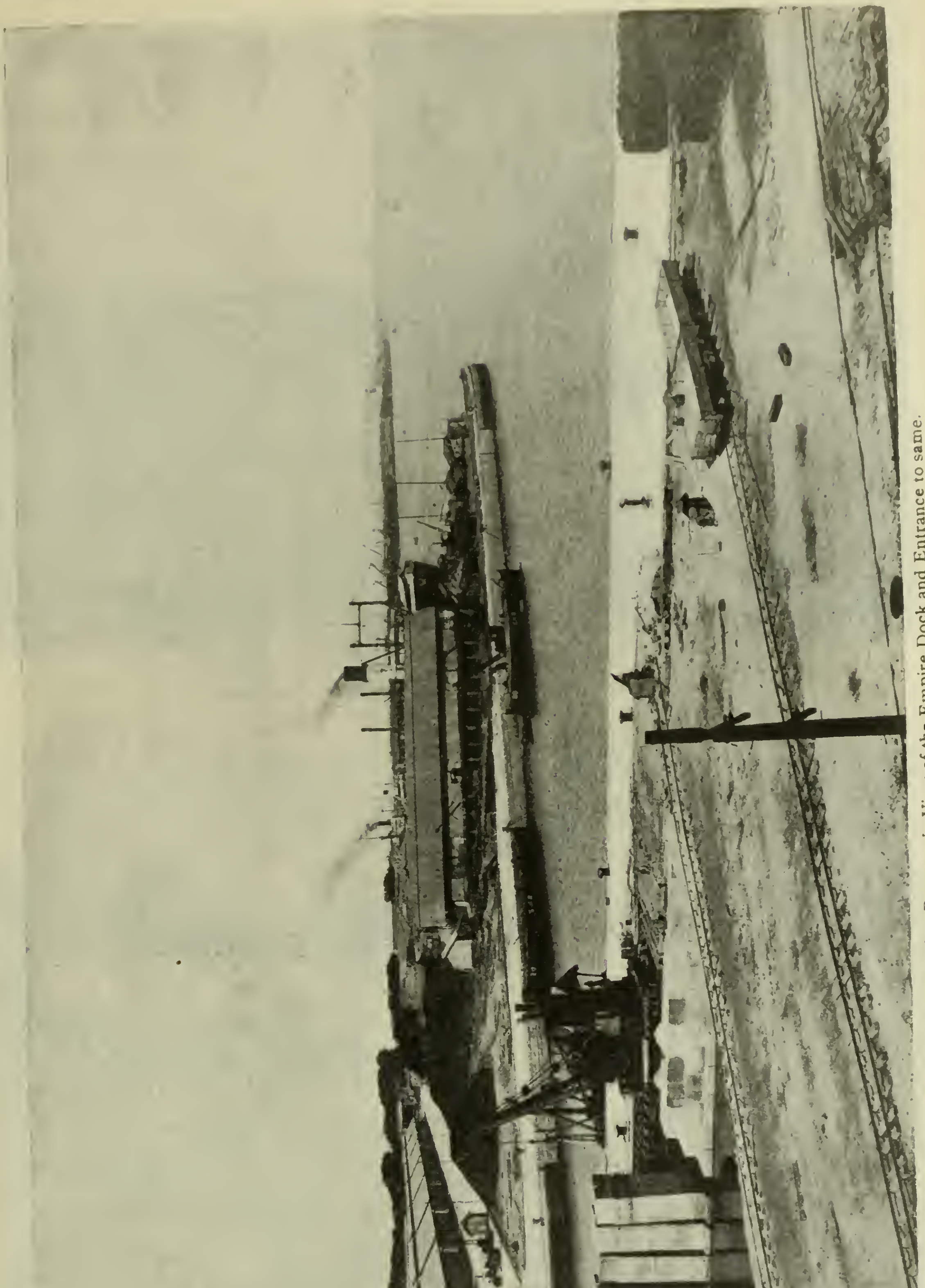


Fig. 2. Another Panoramic View of the Empire Dock and Entrance to same.

THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

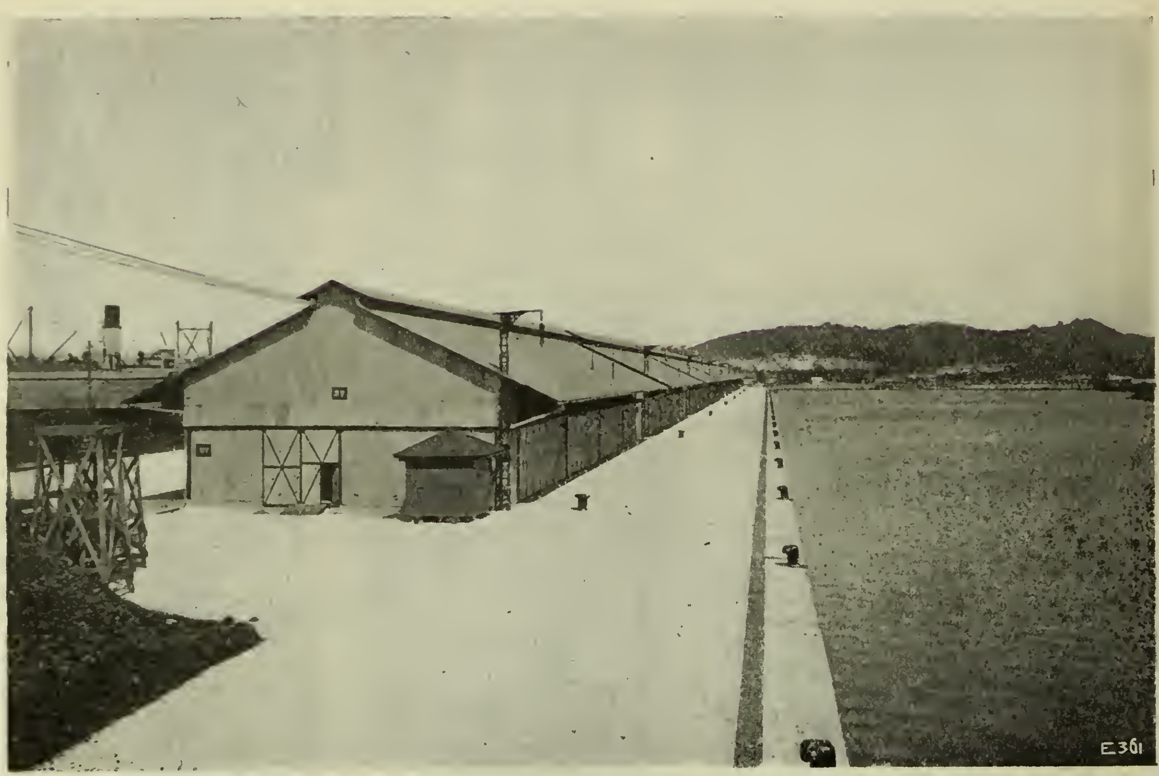


Fig. 3. Showing one side of the Empire Dock and a Godown.
THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

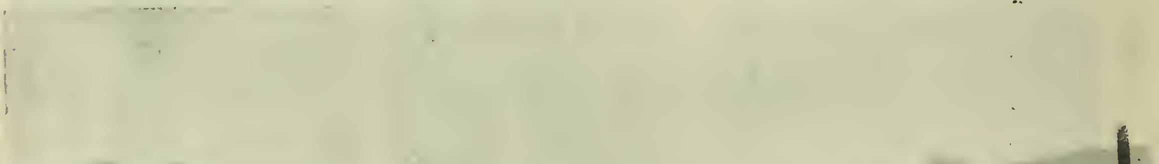


Fig. 4. Shuttering for Decking and Beams.
THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

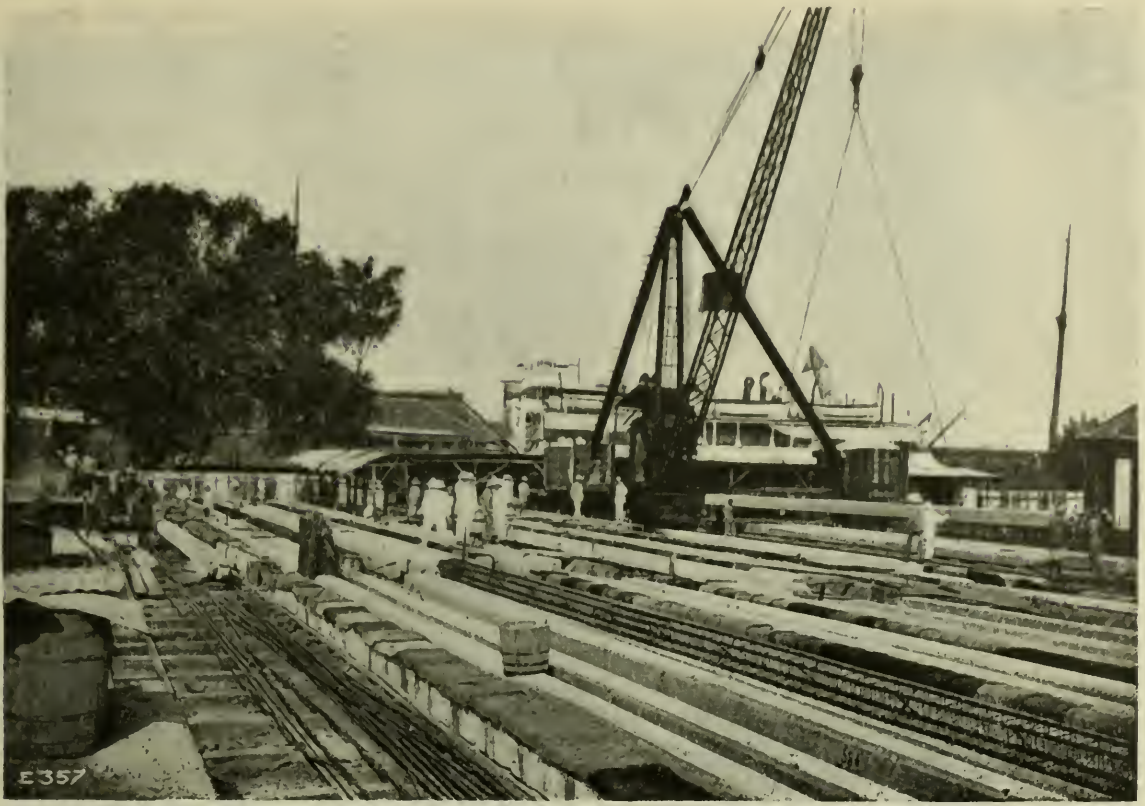


Fig. 5. The Pile-making Yard.
THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

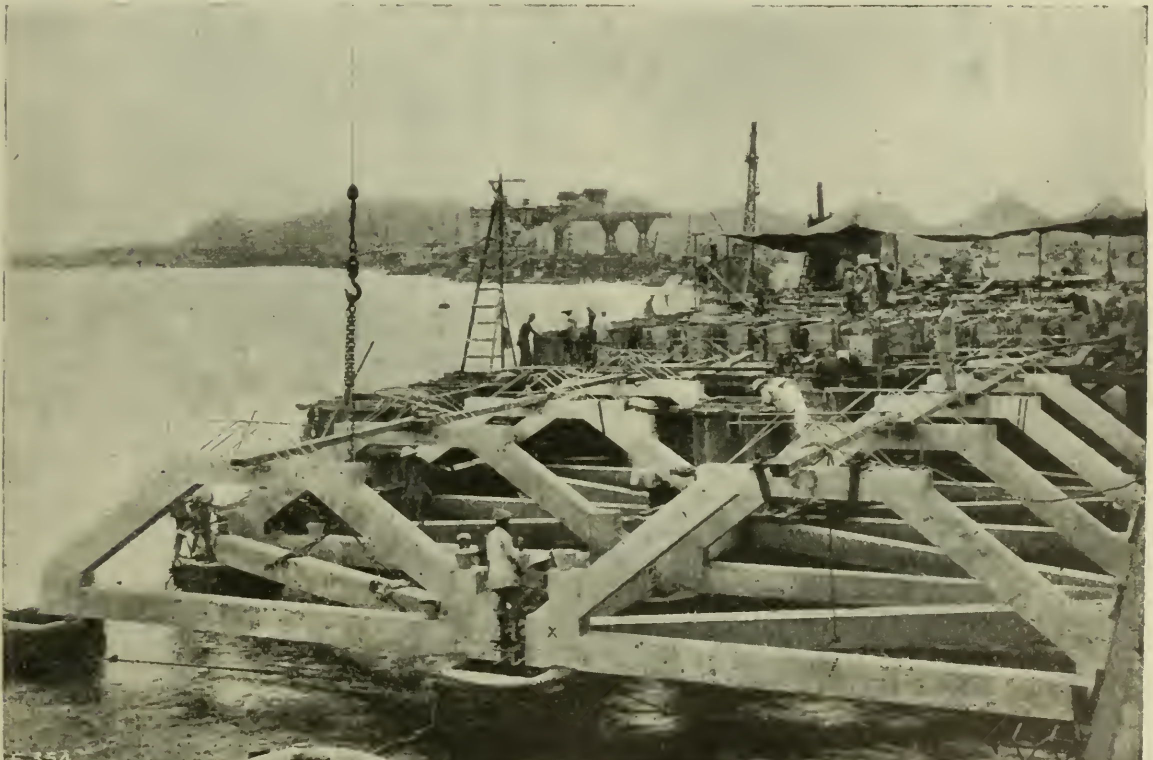


Fig. 6. Showing Trusses and Bracing for the Reinforced Concrete Wharf.
THE EMPIRE DOCK AND THE NEW QUAYS, SINGAPORE.

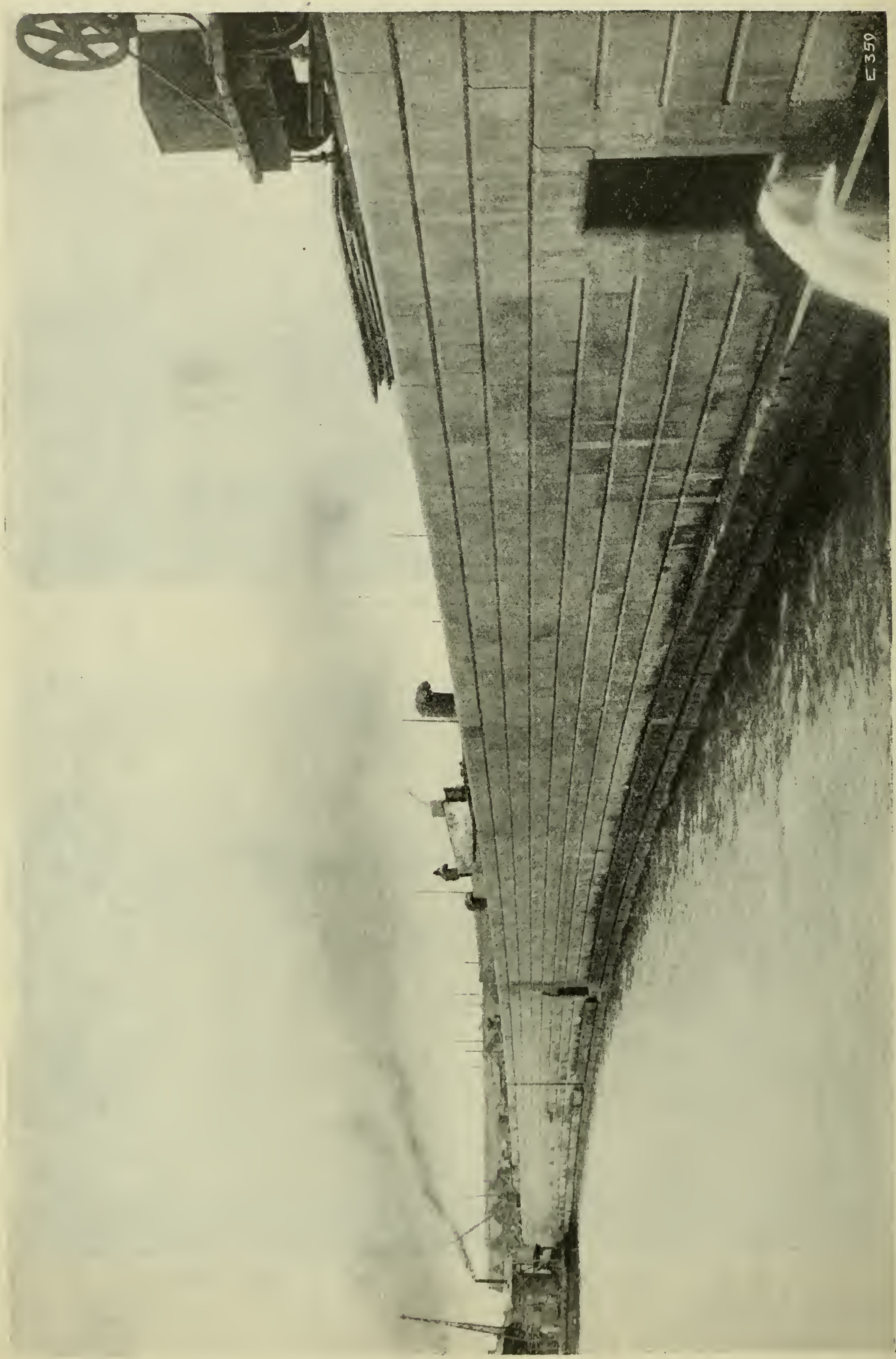


Fig. 7. The Reconstructed Wharf.

The Empire Dock and the New Quays at Singapore.

wharf. This view shows the masons in the act of setting the moulded concrete ashlar facing in the superstructure of the blockwork wall.

Fig. 4 shows the shuttering for the decking and beams above the trusses.

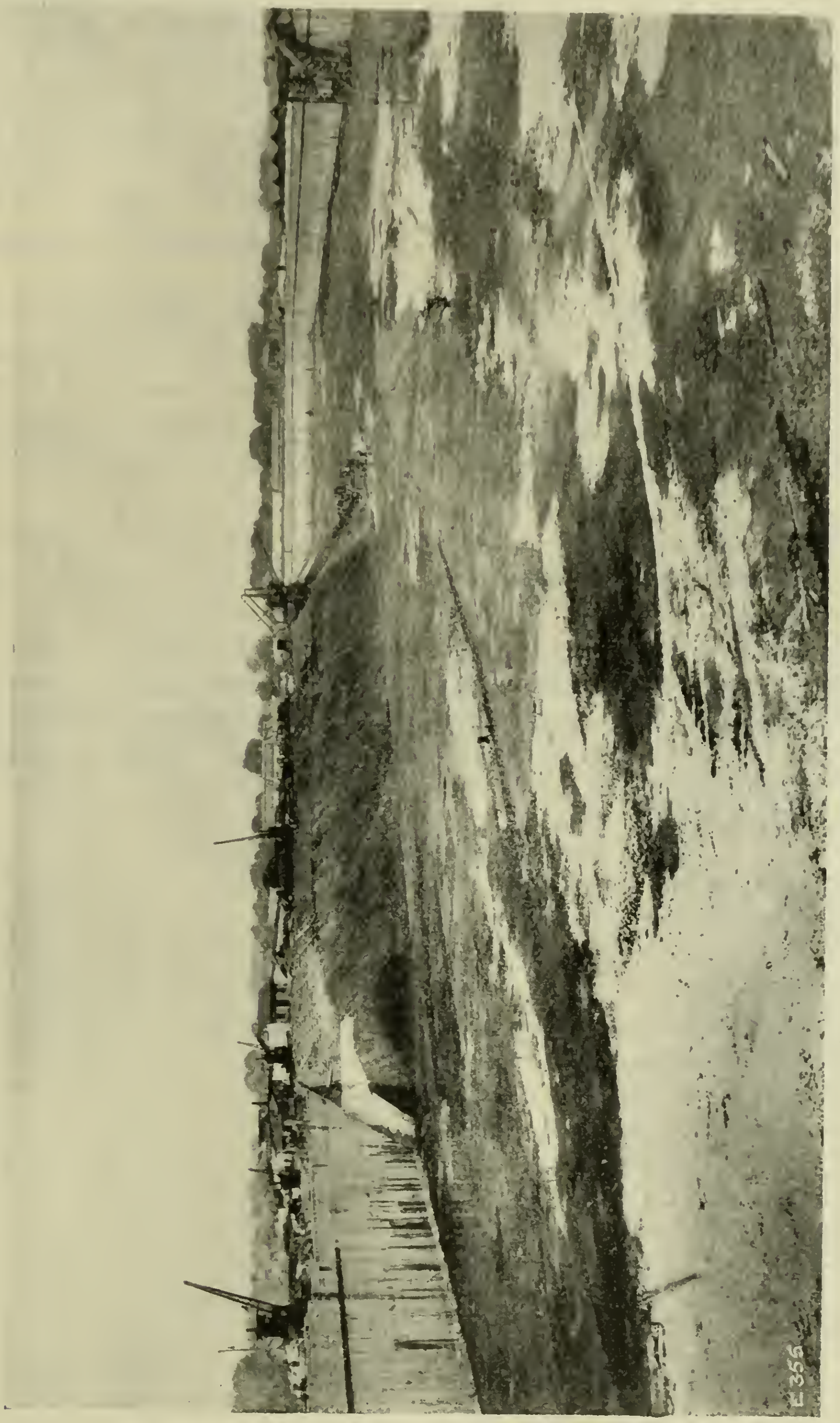


Fig. 8. A View of the Dock taken shortly before water was admitted.
The Empire Dock and the New Quays, Singapore.

Fig. 5 is a view in the pile-making yard for the reinforced concrete wharf The piles were 15 in. square sections and varied in length from 40 ft. to 67 ft., and were handled in the yard by a 10-ton derrick crane.

Fig. 6 shows the trusses and low-water bracing for the reinforced concrete wharf. These trusses are carried on the piles enclosed by cylinders and filled in with concrete. The wire guys in the foreground are for holding the cylinders in place whilst setting the trusses.

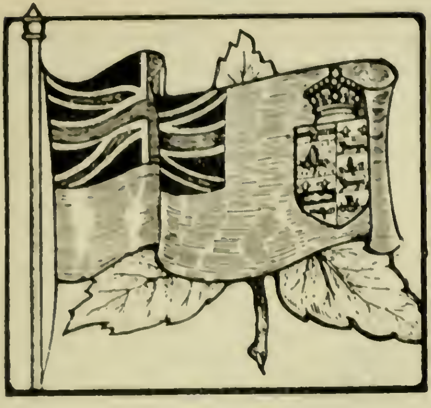
Fig. 7 gives a good idea of the reconstructed wharf, and shows the concrete ashlar facing at low water and storm water outfalls, the quoins for which were all premoulded.

Fig. 8 is a view of the dock taken shortly before water was admitted to it.

A fresh-water supply and electric light are being installed upon the quays, and when the works are completed roads 75 ft. wide will run around the dock, and ten warehouses, 200 ft. by 50 ft., and four others, 250 ft. by 100 ft., will have been erected, which together will give storage space for 45,000 tons of merchandise.

Some idea of the magnitude of the work may be gained from the fact that 1,864,000 cub. yds. of earth have been excavated, and that this mass of earth has served to reclaim 150 acres of land which was formerly a tidal swamp; also that the consumption of Portland cement (which has been mostly supplied by the Associated Portland Cement Manufacturers [1900], Ltd.) has been 40,000 tons.

The whole of the work was carried out for the Singapore Harbour Board by Messrs. Topham, Jones and Railton, of Gt. George Street, Westminster, in accordance with the designs and under the direction of Messrs. Coode, Matthews, Fitzmaurice and Wilson, of 9, Victoria Street, in conjunction with Mr. J. R. Nicholson, C.M.G., engineer and general manager to the Singapore Harbour Board, as joint engineer. Messrs. Mouchel and Partners, Ltd., of 38, Victoria Street, S.W., prepared the working details of the reinforced concrete work.



PROPORTIONING THE MATERIALS OF MORTARS AND CONCRETES BY SURFACE AREAS OF AGGREGATES.

By CAPT. LLEWELLYN N. EDWARDS,
Supervising Engineer of Bridges, City of Toronto, Ont.

Continued from March issue, page 133.

Having determined the means of securing a " normal," uniform mix, little difficulty was encountered in the preparation of test mortars intended to establish the efficiency of the primary theory of this method—namely : " The strength of mortar is primarily dependent upon the character of the bond existing between the individual particles of the sand aggregate. Upon the total surface area of these particles depends the quantity of cementing material."

Test mortars were prepared as follows :—

1. A series of nine mortars, composed of sands varying widely in their granulometric composition, combined in each case with a quantity of cement proportioned in the relation : 1 g. cement to 13 sq. in. sand area.

2. A series of four mortars, composed of a sand of uniform granulometric composition, combined in each case with quantities of cement proportioned in the relation : 1 g. cement to 10, 15, 20 and 25 sq. in. sand area, respectively.

3. A series of two mortars, composed of the sands used in two of the concrete tests, combined in each case with a quantity of cement proportioned in the relation : 1 g. cement to 15 sq. in. sand area.

It is evident that, if the primary theory of this method of proportioning is correct, the ultimate strengths obtained from the first series of tests will be uniform and equal. It is equally evident that the relation of the ultimate strength to the cement content of the mortar is securable from the results of the second series. However, it must be borne in mind that the strengths obtained in each series are not necessarily the same as those which might be obtained from the use of a sand having its origin in a different rock material. The third series of tests provides a means of comparing the ultimate strengths obtained from mortars of normal consistency with those obtained from the mortar content of concretes forming a part of the general tests herein described.

Table VII. shows the composition of the test mortars of the three series described above. It also shows for each mortar the ratio existing between the cement content and the sand aggregate, by weight.

Fig. 8 shows the average ultimate compressive and tensile strengths obtained from test specimens of the first and third series, while *Fig.* 9 shows the results obtained from the specimens of the second series.

Fig. 10 was deduced from the information contained in Tables VI. and VII. It shows by percentages the relation between the surface area of sand *E* and that of each of the other sands described in Table V. The economy of the surface-area method of proportioning is here apparent.

TABLE VII.—STRENGTH TESTS : COMPOSITION OF MORTARS.

TEST SERIES NO. 1

CEMENT CONTENT—1 G. : 13 SQ. IN.

Sand Letter.	Surface Area per 1000 g., sq. in.	Cement, g.	Water, cc.	Ratio of Cement to Aggregate by Weight.
A	5 856.6	450 5	128.0	1 : 2.22
B	5 106.1	392.0	111 5	1 : 2 55
C	7 683.7	591.0	134 5	1 : 1.69
D	6 758 4	520.0	148.0	1 : 1 92
E	12 816 4	986.0	280 5	1 : 1.12
F	6 769.1	521 0	148.0	1 : 1 92
G	4 182.0	321.5	91.5	1 : 3.11
H	6 564.6	505.0	143 5	1 : 1.98
I	6 564 6	505.0	143.5	1 : 1.98

TEST SERIES NO. 2

CEMENT CONTENT—1 G. : 10, 15, 20 AND 25 SQ. IN.

Sand Letter.	Surface Area per 1000 g., sq. in.	Cement, g.	Water, cc.	Ratio of Cement to Aggregate by Weight.
F	6769	677.0	183.0	1 : 1.47
	6769	451.0	132.5	1 : 2.21
	6769	338 5	105.5	1 : 2.95
	6769	270 5	92.5	1 : 3.61

TEST SERIES NO. 3

CEMENT CONTENT—1 G. : 15 SQ. IN.

Sand Letter.	Surface Area per 1000 g., sq. in.	Cement, g.	Water, cc.	Ratio of Cement to Aggregate by Weight.
O	7353·4	490.0	144.0	1 : 2.41
Q	6391.0	426.0	126.0	1 : 2.35

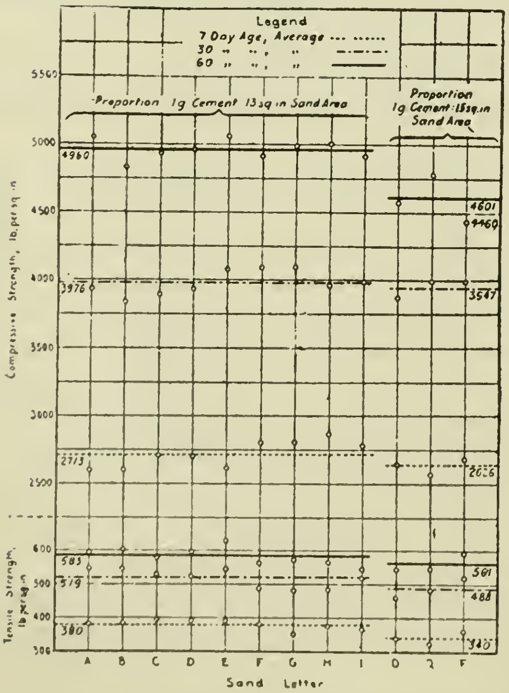


Fig. 8. Strength Tests—Compressive Strengths of 2-in. Mortar Cylinders and Tensile Strengths of Mortar Briquettes.

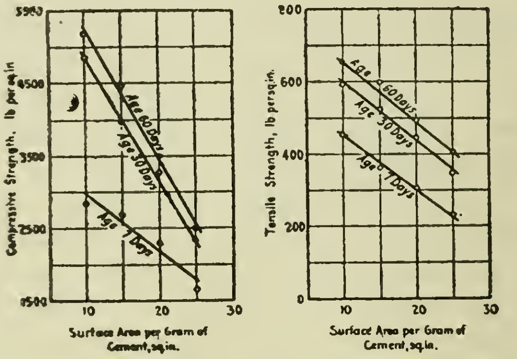


Fig. 9. Strength Tests—Compressive Strengths of 2-in. Mortar Cylinders and Tensile Strengths of Mortar Briquettes, 1 g. Cement : 10, 15, 20 and 25 sq. in. Sand Area.

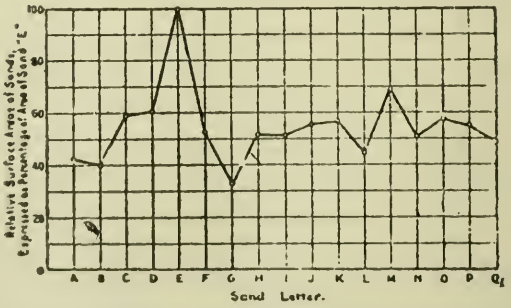


Fig. 10. Relative Surface Areas of Sands (deduced from Tables VI. and VII.).

CONCRETE STRENGTH TESTS.

Fig. 11 shows the average strengths obtained from the tests of concretes and from the tests of mortars secured from the mortar portions of these concretes. For purposes of direct comparison, the average of strengths obtained from normal consistency mortars, sands *O* and *Q*, are also shown. In this connection a comparison with *Fig.* 13 is of interest.

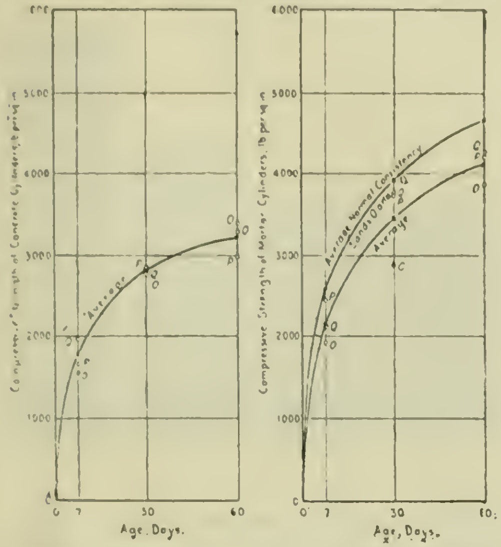


Fig. 11. Compressive Strengths of Mortar and of Concrete Test Cylinders.

The weaker strength of the concretes as compared with the mortars is doubtless due in part to the weakening effect of cleavage planes produced by the stone aggregate. A comparison of the strengths shown in *Fig.* 11 indicates a probability that by this method of proportioning, the relative values of sands for use in concretes can be determined from a comparison of mortars, the cement content of which bears a common ratio to the areas of the sands compared and the water content of which is the same as that to be used in the proposed concrete. The low strength of sand *O* mortar at an age of 30 days is probably due to the weakening effect of stone particles over $\frac{1}{4}$ in. in size contained in the mortar as a result of screening through a $\frac{3}{8}$-in. screen.

MISCELLANEOUS TESTS.

In connection with the foregoing tests three miscellaneous tests were made having an indirect relation to the results obtained therein. A description of these tests together with the results obtained, follows.

Effect of Consistency of Mix upon the Strength of Mortars.—This test was undertaken with the object of securing information indicating the change of strength resulting from (1) the mixing, either by intent or by accident, of test mortars of too wet consistency, and (2) a variation of the water content of the mix from that required to produce a " normal " consistency mortar to that producing a " sloppy " mix, such as is frequently found in concretes of too wet consistency.

In each of these tests the relation of the cement content of the mix to the surface area of the sand aggregate was constant for each series ; that is, for the first series a proportion 1 g. cement to 15 sq. in. sand area, and for the second series a proportion 1 g. cement to 10 sq. in. sand area. Sand *Q* was used in the first series and sand *F* in the second series.

Table VIII. shows the compositions of the mortars and *Figs.* 12 and 13 show the average strengths obtained from test specimens for each series of tests.

Weight-Volume, Cement Paste Test.—This test was made as a check upon the common assumption that 110 lb. of dry cement produces 1 cu. ft. of cement paste. It was found that 2,000 g. of cement when thoroughly mixed with 445 c.c. of water (normal consistency) produces 1,140 c.c. of paste, corresponding to 109·52 lb. of dry cement to produce 1 cu. ft. of paste.

An increase of 35 c.c. in the volume of water used produced an increase of 20 c.c. in the volume of paste, which corresponds to a decrease of 2·11 lb. in the weight of dry cement required.

Bulking Effect of Cement Content of Mortars.—The bulking effect of the cement was especially noticeable in test mortars in which the granulometric composition or grading

Table VIII.—Consistency Tests: Composition of Mortars

TEST SERIES NO. 1c.
CEMENT CONTENT—1 G. 15 SQ. IN.—SAND Q.

Consistency	Surface Area per 1000 g. sq. in.	Cement, g.	Water, cc.	Percentage of Water to Cement and Sand.
Normal	6391	426	124	8.69
Medium	6391	426	136	9 54
Wet	6391	426	147	10 31

TEST SERIES NO. 2c.
CEMENT CONTENT—1 G. 10 SQ. IN.—SAND F.

Consistency	Surface Area per 1000 g. sq. in.	Cement, g.	Water, cc.	Percentage of Water to Cement and Sand.
Normal	6769	677	183	10 91
First	6769	677	217	12.94
Second	6769	677	251	14 97
Third	6769	677	285	16 99
Fourth	6769	677	319	19 02
Fifth	6769	677	353	21 05

of the sands was such as to give comparatively large computed surface areas. Its variation with the proportion of cement used in relation to the surface area was also noted. Both conditions are in full accord with the primary principle of this method of proportioning.

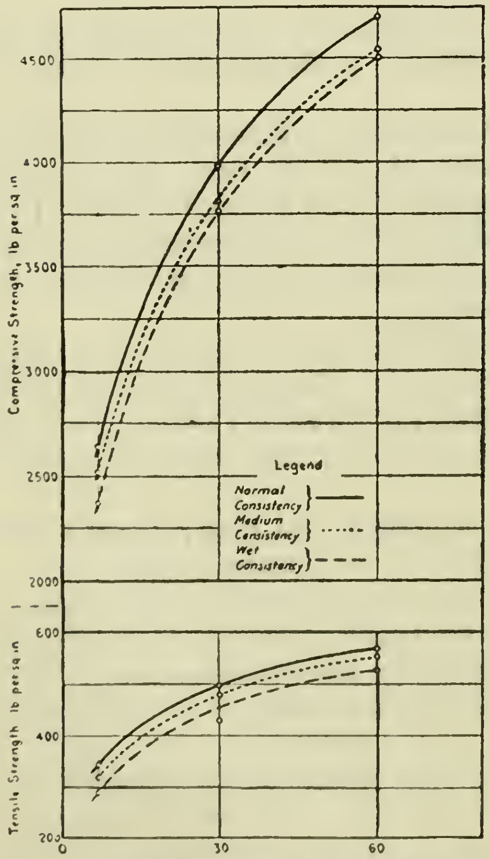


Fig. 12. Strength of Mortars of different consistencies and ages; Sand Q; 1 g. Cement: 15 sq. in. Sand Area.

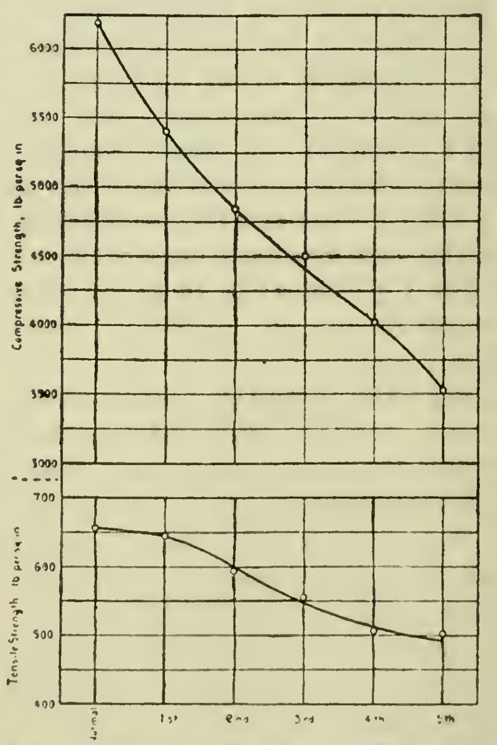


Fig. 13. Strengths of Mortars of different consistencies. Age 60 days; Sand F; 1 g. Cement: 10 sq. in. Sand Area.

Fig. 14 shows a series of mortar cylinders in each of which 1,200 g. of sand *F* were used and the cement content was successively decreased in the proportions: 1 g. cement to (*a*) 5, (*b*) 10, (*c*) 15, (*d*) 20, (*e*) 25, (*f*) 30, (*g*) 35 and (*h*) 40 sq. in. sand area. The cylinder (*i*) at the extreme right-hand end of the series contains only a sufficient quantity of cement (15 g.) to retain the 1,200 g. of sand in a cylindrical form, thus permitting a close comparison with the compacted bulk of the sand alone. *Fig.* 15 shows the relative percentages of volume in relation to the volume of the "sand" cylinder above described.

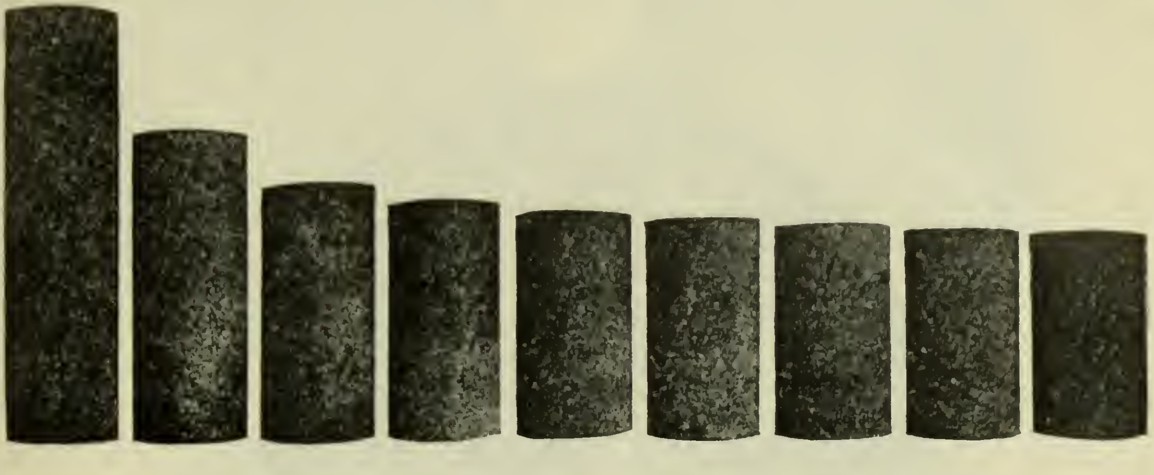


Fig. 14. Mortar Cylinders in which the Cement Content was decreased.

In this connection it is of interest to note that the void in sand *F* was found to be 31·3 per cent. By the void method of proportioning the quantity of cement paste necessary to fill the void in 1,200 g. of sand bulking 41·29 cu. in. would be 12·92 cu. in., requiring 374·3 g. of dry cement. With no allowance for the separating of the sand particles, this corresponds approximately to a cement content, 1 g. cement to 22 sq. in. sand area by the surface area method.

Figs. 14 and 15 give no evidence of a marked change in the increment of increase of volume due to the cement content exceeding that of the void.

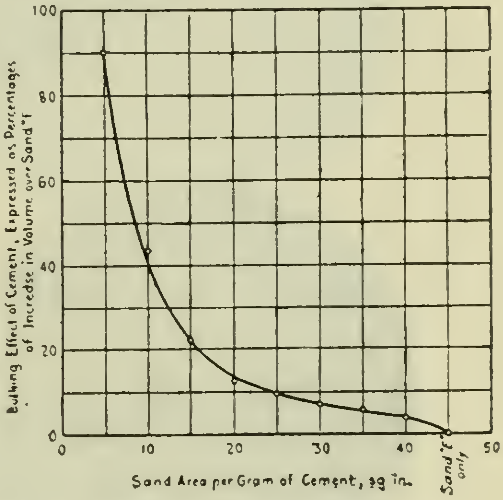


Fig. 15. Relation of Cement Content to Bulk of Mortars. Sand F.

OBSERVED PHENOMENA OF TESTS.

Voids in Mortar.—Mortars produced under ordinary conditions invariably contain voids having two general sources of origin—namely: (1) Those due to globule-like accumulations of water which evaporate, leaving so-called water voids, and (2) those due to air adhering to the surfaces of the sand particles or to air entrained during the mixing of the component materials, producing air voids.

Fig. 16 shows a photomicrograph (× 75) of neat cement as it exists in standard briquettes. The effect of the surface tension of water is shown here by the great number of voids. This well-known attribute of water renders it impossible to secure, even in the richest mortars, an unbroken film of cementing material surrounding the particles of sand aggregate.

Resistance to Impact.—Hardness, toughness, etc., were roughly tested under the impact of hammer blows, " knob " ends of briquettes and fragments of broken cylinders being used for this purpose. Mortars having an equal cement content in relation to the surface area of the sand aggregate showed a most remarkable uniformity when tested in this rather crude way.

Texture of Mortars.—A careful microscopic examination of the cement matrix of the mortars containing test sands *A* to *I*, inclusive, proportioned as indicated in Table VII., showed, in all cases, an equal uniformity of distribution. In a comparison of mortars containing a less proportion of cement in relation to the surface area of the aggregate this condition was found to be equally true.

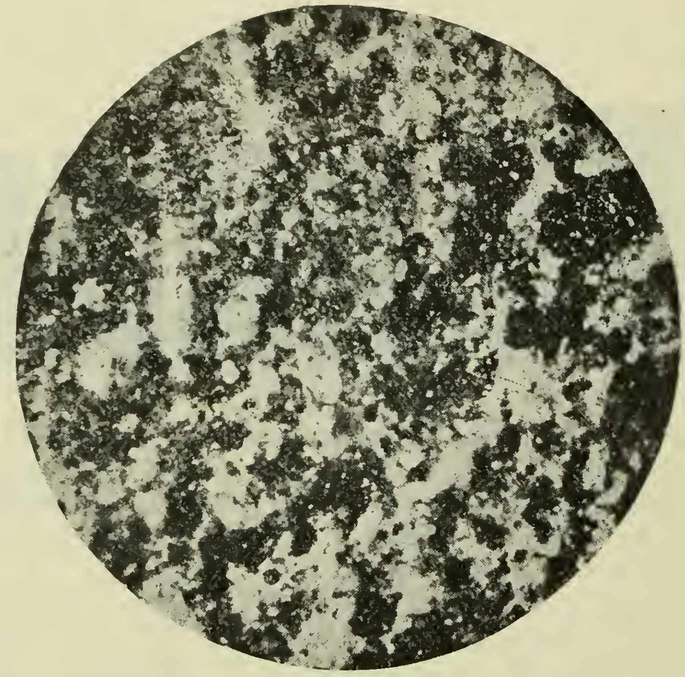


Fig. 16. Texture of Fractured Surface of Neat Cement Briquette (×75).

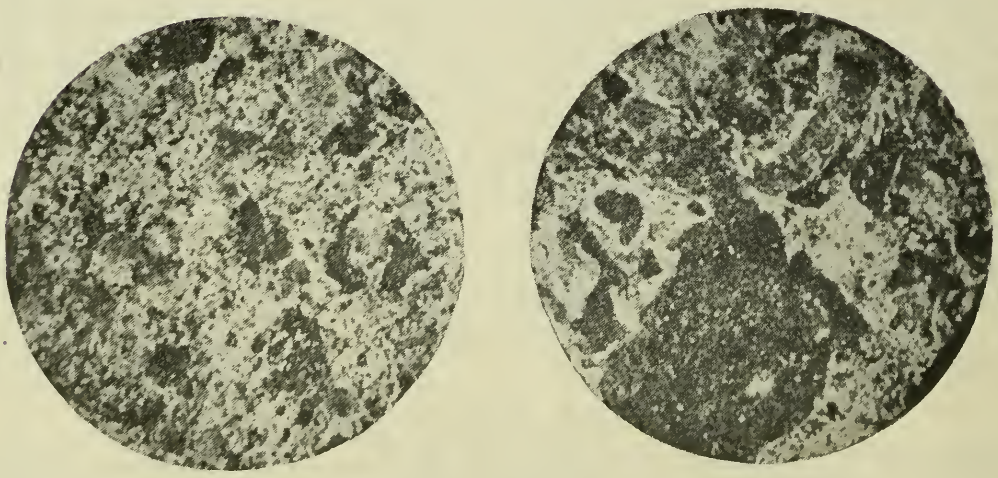
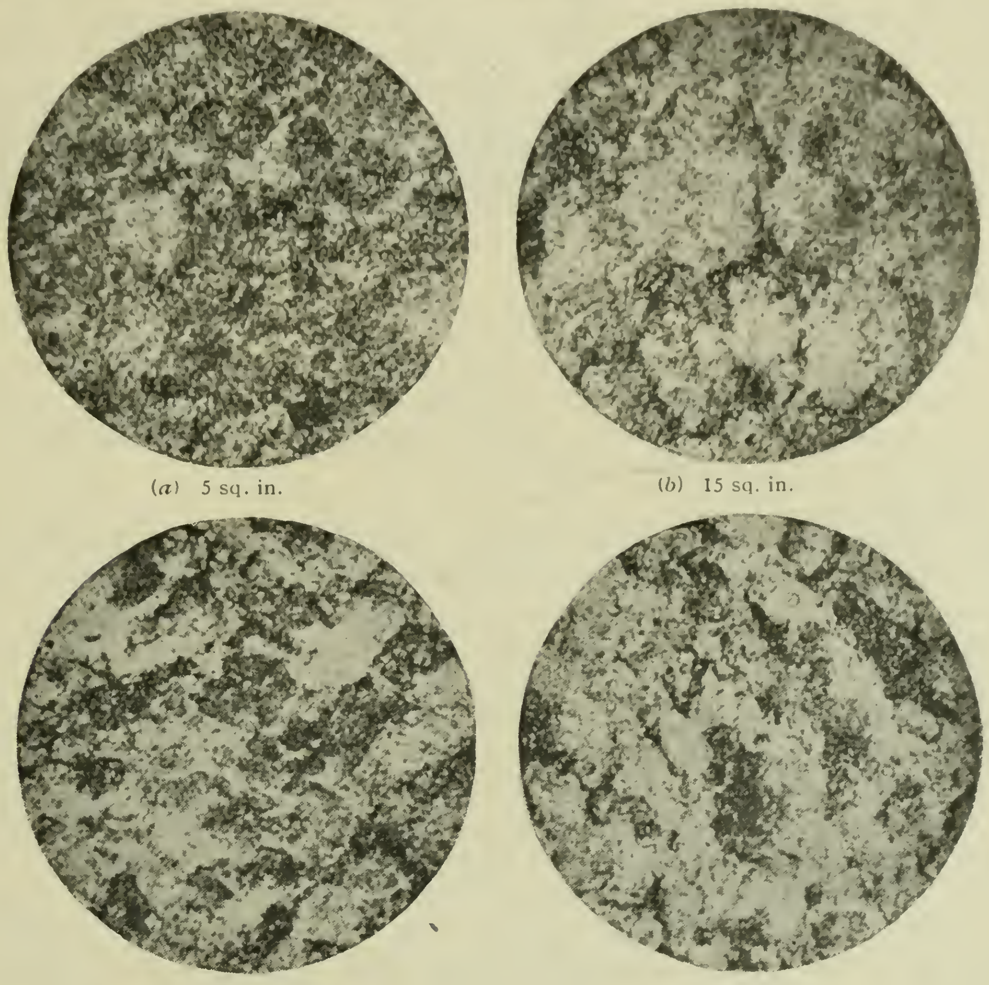

(*a*) Sand A. (*b*) Sand D.

Fig. 17. Texture of Fractured Surfaces of Mortars proportioned 1 g. Cement : 13 sq. in. Sand Area (×20).

Fig. 17 shows photomicrographs (× 20) of the fractured surfaces of mortars, proportioned 1 g. cement to 13 sq. in. sand area, in which the sands are of distinctly different granulometric composition.

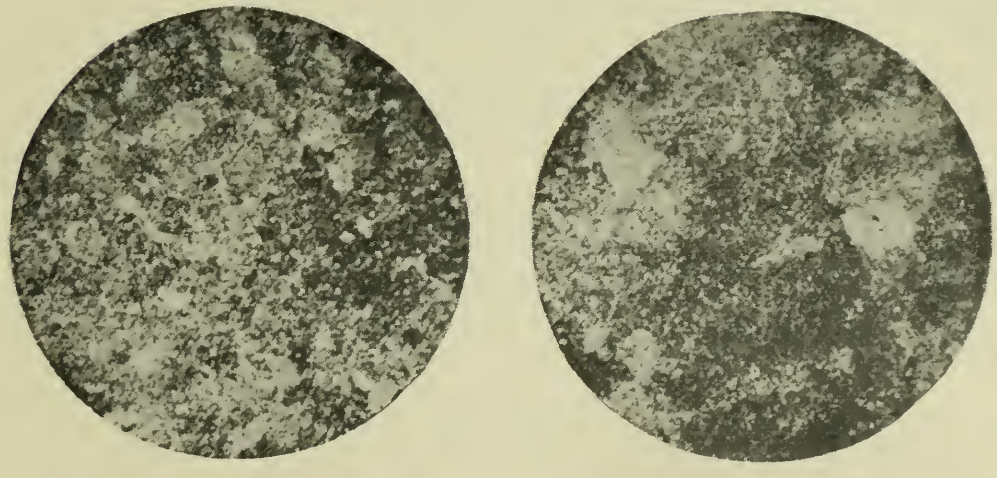
Fig. 18 shows four photomicrographs (× 20) of fractured surfaces of mortars varying in their cement content as follows: 1 g. cement to 5, 15, 25 and 35 sq. in. sand area. The specimens for photographing were taken from the mortar cylinders shown in *Fig.* 14. The decrease in the quantity of the cement matrix is readily recognisable by the decrease of matrix adhering to the particles of sand aggregate.



(*a*) 5 sq. in. (*b*) 15 sq. in.

(c) 25 sq. in. (*d*) 35 sq. in.

Fig. 18 Texture of Fractured Surfaces of Mortars proportioned 1 g. Cement : 5, 15, 25 and 35 sq. in. Sand Area (× 20).



(*a*) ×20. (*b*) ×75

Fig. 19. Texture of Medina Sandstone.

It is of special interest to note that, although the first-mentioned mix contained, by weight, a greater quantity of cement than of sand aggregate, and, although the cement matrix may be said to " thoroughly envelop " the particles of the aggregate, it nevertheless contains myriads of minute voids which are probably of water origin.

Fig. 19 shows photomicrographs (× 20, × 75) of Medina sandstone. The comparatively small amount of cementing material holding the particles of sand in place is of special interest.

Effect of Excess Water.—The proper function of the water content of a mortar mix is to combine with the cement in producing the pasty matrix which, when set, binds the particles of the aggregate into a uniformly strong, stone-like material. The addition of a comparatively small quantity of water in excess of that required for the fulfilment of its proper function produces a very marked effect upon the structure of the cement matrix.

This change in the structure of the cement matrix can be readily seen by the aid of a microscope ; but, like sunlight, it is far easier seen than described. However, in the microscopic examination of the fractured surface of a " normal " consistency specimen, say, at 50 to 75 diameters magnification, the observer takes special note of three conditions of the matrix, namely :—

1. It is greyish in colour.
2. It adheres to the particles of aggregate in amorphous pasty-appearing masses.
3. It contains myriads of minute voids, permeating the entire formation.

As compared with the above, the cement matrix of a " wet " consistency mortar specimen presents a radically changed appearance, that is :—

1. Its colour is changed from greyish to nearly a milky white.
2. It no longer adheres firmly to the surfaces of the aggregate, but instead appears as a comparatively loose, semi-crystalline formation, which, although containing few, if any, real crystal forms, may be compared to rather loosely massed snow crystals.
3. It contains, when closely examined, comparatively few of the well-defined globular-shaped voids observed in a " normal " specimen.

When examined under a lower magnification, say, 16 to 25 diameters, the matrix of wet-consistency mortar specimens presents a loose " sugary " or granular appearance. Doubtless this change in the physical structure of the matrix from a comparatively dense, compact material to an attenuated, fluffed up, skeleton-like mass, lacking cohesiveness and other attributes of strength, discloses the deep, underlying, but nevertheless primary cause contributing to the low strength, friability, shortness and other undesirable properties found in wet-consistency mortars and concretes.

(To be continued.)

A CONCRETE-LINED OIL RESERVOIR, EL SEGUNDO, CAL.

APPLICATION OF CONCRETE TANKS TO OIL STORAGE.

By J. E. FREEMAN.

It is interesting to note from Mr. Freeman's article the increasing use of concrete for Oil Storage Tanks in America. Our illustrations are taken from a Pamphlet issued by The Portland Cement Association, U.S.A.—ED.

THE idea of concrete tanks has not been a new or untried proposition, as many might believe, but such tanks have been in use for a number of years in different parts of the United States, and investigations with which the author has been connected have shown that these tanks, by experience, have proved satisfactory containers for fuel oil. There are even concrete tanks in use for the lighter crude oils and the more volatile products, such as kerosene, gasoline and benzine.

There are two distinct types of concrete containers—one, the large slope-wall reservoir such as used in the California fields and in some sections of the south-west for the storage of heavy asphaltic oils ; and the other, the underground concrete storage tank with vertical walls, which is either circular or rectangular in design. In the earthen reservoirs used during the early periods for the storage of the heavier oils, the seepage in the unlined reservoir amounted to 4 per cent. a year. It has been shown that by lining such reservoirs with concrete this loss could be reduced to 1 per cent. or less, and with the present prices for oils the saving thus secured is a considerable item.

A paper on the California type of concrete-lined reservoirs, published in the Transactions of the American Society of Civil Engineers for December, 1916, described in detail this method of construction, and showed that the concrete was impermeable to oils of low gravity under heads up to 24 ft. The chief engineer of a California oil company stated that test holes cut in the concrete of such reservoirs after they had been in use for a number of years showed penetration of but a fraction of an inch into the concrete, and that in many cases the natural dampness of the concrete itself seemed to prevent the oil being absorbed by capillary attraction. Bulletin No. 155 of the Bureau of Mines further comments on the storage of low gravity oils in these slope-wall concrete containers, and states that samples from bottoms of reservoirs 20 ft. in depth that have been in use for a period of five years had indicated practically no penetration

A 500,000 barrel reservoir at El Segundo, Cal., may be cited as an example of this type. It has a diameter of 400 ft., with a depth of 22 ft. at the centre and 19ft. at the walls. The concrete lining is about 3 in. in thickness, reinforced with wire mesh. Other large reservoirs of similar type in the California fields are, one at Bakersfield of 750,000 barrels capacity, built in 1913 ; and another at Port Richmond of 1,000,000 barrels capacity, built in 1909. These reservoirs were built usually with wooden roofs without earth cover.

A more recent development of this slope-wall type of construction is a storage tank built at a glass company plant at Columbus, Ohio, in 1917. This is 72 ft square at the top with side walls on a 1 to 1 slope, 10 ft. deep at the sides and 12 ft. at the centre, with a capacity of about 300,000 gallons. The walls and floor are 6 in. thick, reinforced in two directions ; a 9-in. concrete roof supported by reinforced concrete beams on 8-in. cast-iron columns was finished with a coating of rich mortar, and then covered with a dry cinder fill that was given a ¾-in. top coat of cement mortar. The basin proper was given about six weeks to harden, and the roof about three weeks, before the tank was placed in service (see *Fig.* 2).

The underground concrete tank, however, with vertical side walls, is more adapted to average conditions and to the storage of the lighter oils, and it is here that important advantages are to be derived from underground construction. In the past losses in evaporation and seepage from imperfect storage, from waste in methods of using fuel oil, etc., have in the Gulf fields alone amounted to at least a half-million dollars in one year. Then there were the losses from fire to increase the total. If the estimate is correct for the territory mentioned, what must have been the losses for the whole country? Losses from seepage and evaporation are avoidable, losses by fire are preventable, and both depend upon proper storage.

The underground concrete tank covered by a foot or so of earth keeps the oil at a fairly even temperature, reducing to a minimum the losses from seepage and evaporation as well as the risk from fire or other causes. The difficulties encountered in attempting to draw fuel oil during cold weather have been prevented in the past by installing a system of piping. Such a system was put in a concrete tank built last year by the Asbestos Protected Metal Company at Economy, Pa., but this system was never once used all during the severe winter of 1917–18 because of the excellent insulating properties of the earth and concrete.

Reduced insurance is a factor in favour of the underground concrete tank. It is understood that in several instances insurance has been obtained on such tanks and contents at a reduction in cost of 50 per cent. Reduction in maintenance and repair charges also constitute yearly savings. All these various items combined will each year offset a considerable part of the original cost of the tank.

Often ground storage space is of great importance to the consumer, and when valuable space must be given to oil tanks little is left for the storage of materials. With the underground system every square foot of surface is available, even the roof of the tank being used, as was demonstrated at a Pennsylvania manufacturing plant, where many feet of steel tubing were piled above concrete fuel oil storage tanks in the plant yard. The company has built this year a group of six additional concrete tanks to supplement the four constructed the year before.

With correct underground construction, the vent is the only means of the oil catching fire, and where crude oil with considerable gasoline content is stored, or where the refined products are placed in the concrete tank, a special vent that has been developed removes even this slight hazard. Such a vent has been installed in a number of systems, and, after a series of tests, insurance companies have given it a high recommendation (see *Fig.* 1).

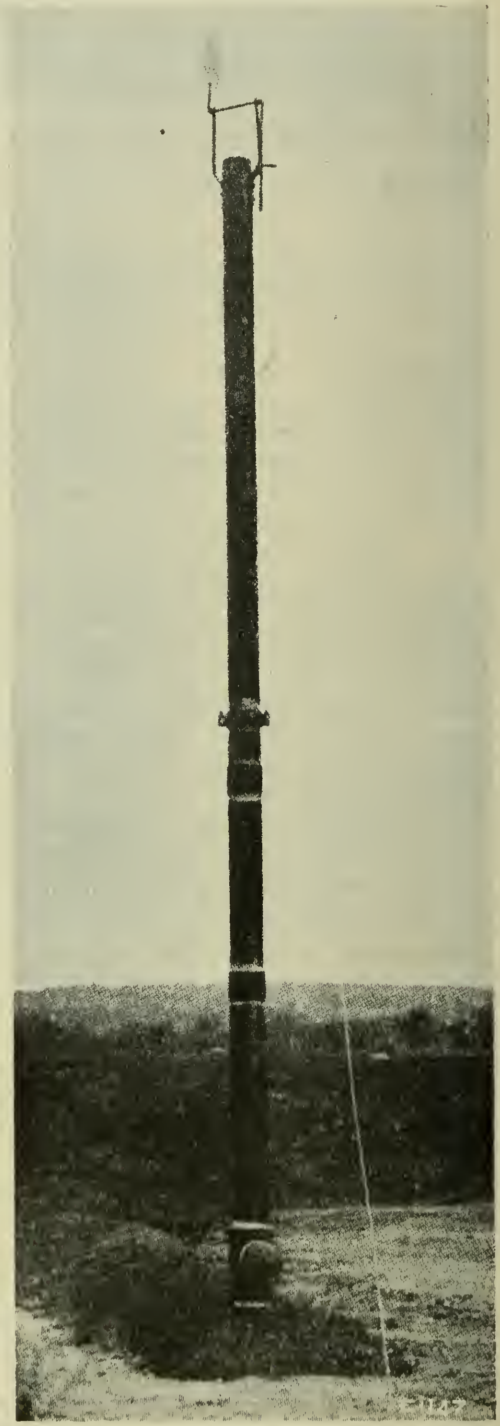


Fig. 1. Safety Vent used on underground Concrete Oil Tanks for Light Oils.

Condition of the underground concrete tanks now in service which hold fuel oil proves that good concrete is not injured, and that with careful design and good workmanship success is assured. A public service company at San Antonio has built a number of concrete tanks for fuel oil storage; one of them has been in use since 1905. A Kansas City company is still using a fuel oil tank built six years ago, measurements on which have shown that there has been no leakage of the oil. Another company, in Garden City, Minn., constructed two 1,000,000 gallon capacity tanks in 1907, and followed these by another tank in 1909. The tanks are in first-class condition, no leakage being experienced, and have been in continuous use since they were constructed, with the exception of occasional cleaning and inspection. At Austin, Minn., there is a 25,000 gallon tank holding gas oil which has been in use since 1913. There is a smaller tank of similar character at Omaha, Nebr., constructed about the same time. Both are in satisfactory condition. At the plant of the Nuskogee Refining Company, Nuskogee, Okla., there are three underground rein-

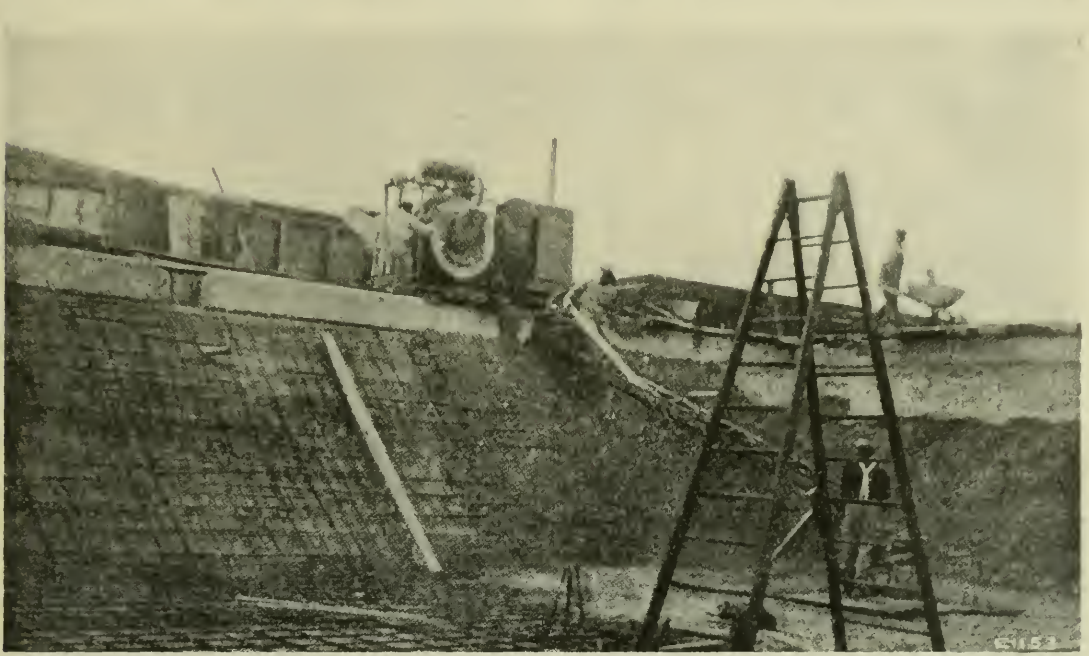


FIG. 2. PLACING CONCRETE FOR WALLS AND FLOOR OF 300,000 GAL. FUEL OIL TANK, MURAL GLASS CO., COLUMBUS, OHIO.

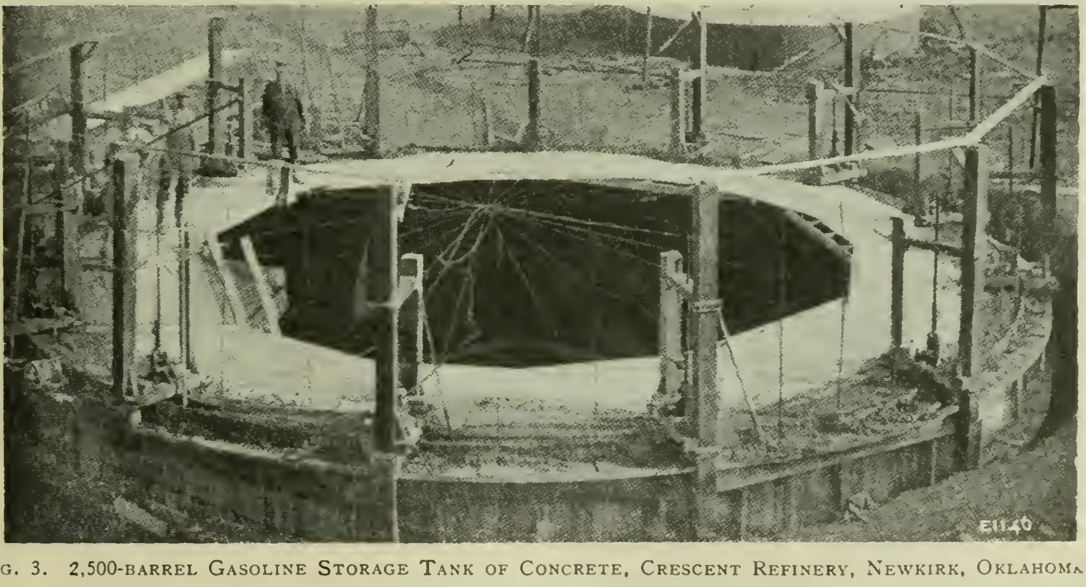


FIG. 3. 2,500-BARREL GASOLINE STORAGE TANK OF CONCRETE, CRESCENT REFINERY, NEWKIRK, OKLAHOMA.

forced concrete tanks of 1,500 barrels capacity each, used for the storage of benzine and finished gasoline.

Two concrete tanks are in use at a refinery in Newkirk, Okla., one of 2,500 barrels for gasoline (see *Fig.* 3), and another of 15,000 barrels capacity for fuel oil. In their construction sliding forms were used similar to those used in building a battery of concrete grain elevators. In this way the concrete is placed continuously without a joint until the roof line is reached. Each of these tanks is provided with a patented fire-resisting vent placed at a short distance from it. The vent is a mechanical device operating a ball valve near the tank, held in position by a fusible link, and protected from the weather by a hood. If vapours form the tank become ignited, the fusing of the link closes the valve and shuts off the vent. Just below the top of the vent pipe is a fire-resisting packing of glass wool through which flame cannot pass. The device has been tested by everyday use as well as by the underwriters, and is proving effective.

There is a small tank at Oilton, Okla., built in 1916 for the storage of the more volatile oils. The tank has a capacity of 500 barrels, and holds Black Panther Cushing oil. The inside surface is coated with a special oilproof paint. The tank has shown no signs of leakage since it was placed in service (see *Fig.* 4).

Concrete tanks for fuel oil storage have been constructed without any special treatment beyond possibly a rich coating of cement mortar applied immediately after the forms are removed, worked into the surface with a wood hand float, and then lightly trowelled. In several instances, however, as an additional precaution, an application of a solution of sodium silicate or water glass has been used.

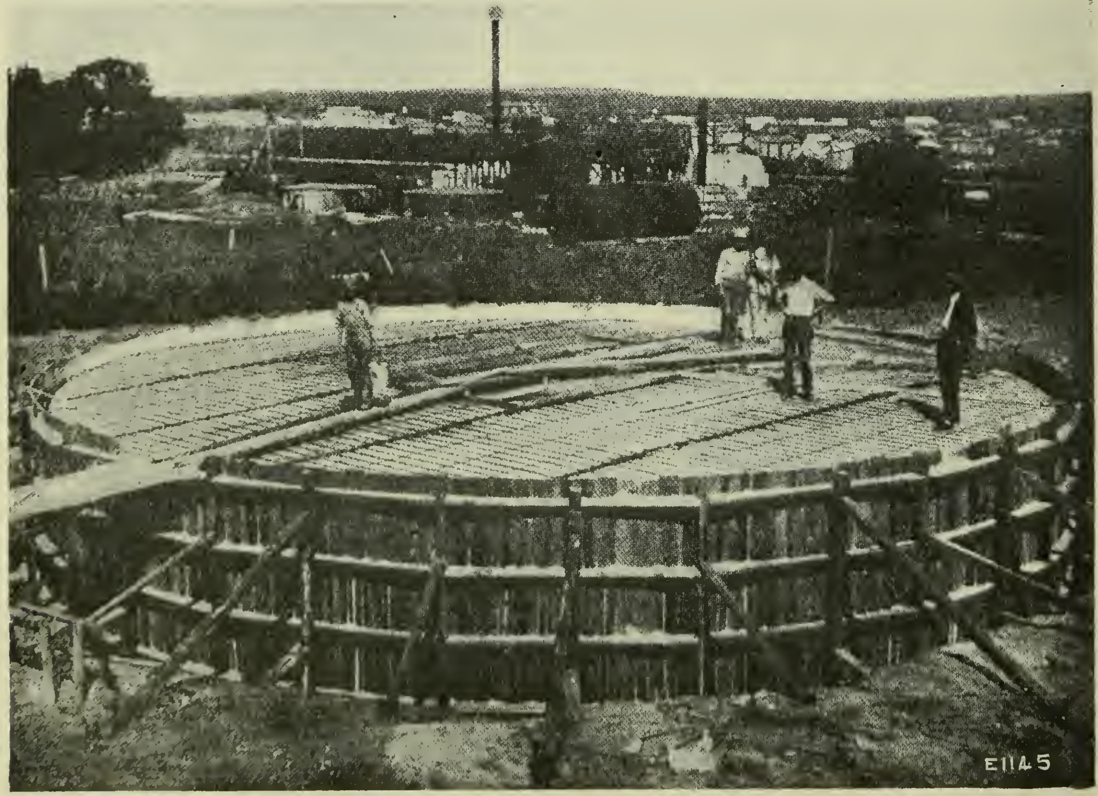
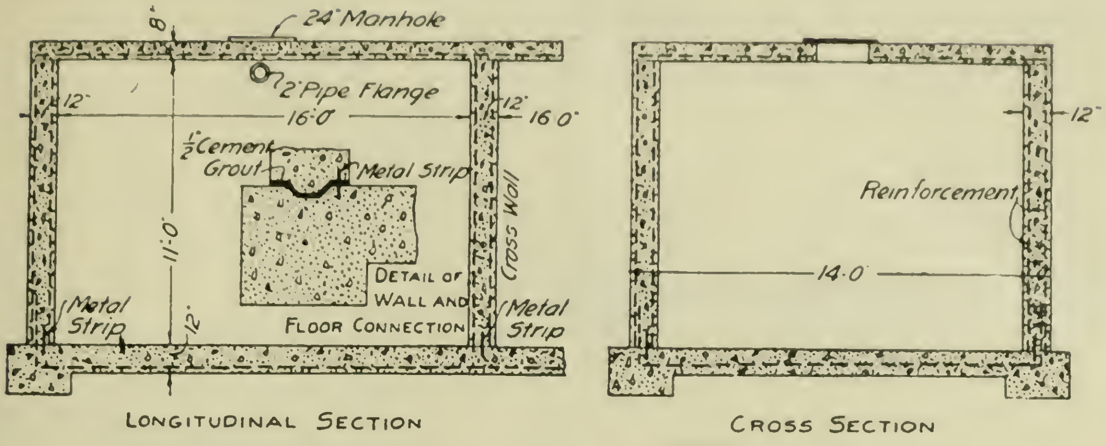


Fig. 4. A 2,500-barrel Underground Tank for Storage of Light Crude Oil, Oilton Refining Co., Oilton, Oklahoma.

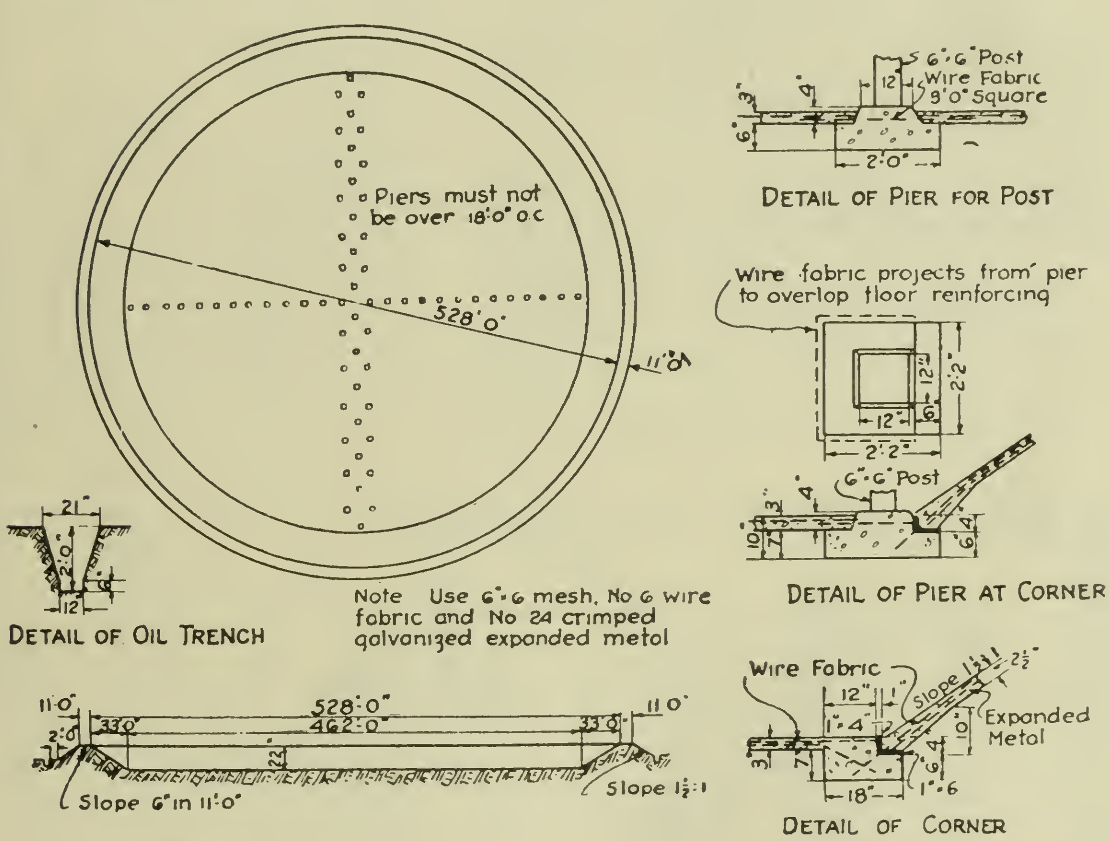
This was the case with the tanks at Garden City, Minn., referred to above. In the construction of these tanks it is customary to use a rich concrete. A 1 : 1½ : 3 mixture was employed in building two 75,000 gallon tanks at the plant of the Union Switch and Signal Company, Swissvale, Pa. The tanks were finished on the inside with a 1 : 1 mortar, and the surface treated with a solution of sodium silicate. The walls and floor were cast continuously to prevent any planes of weakness.

In constructing a rectangular tank at Charles City, Iowa, last year for a local gas company it was necessary to make a joint between the floor and walls and a



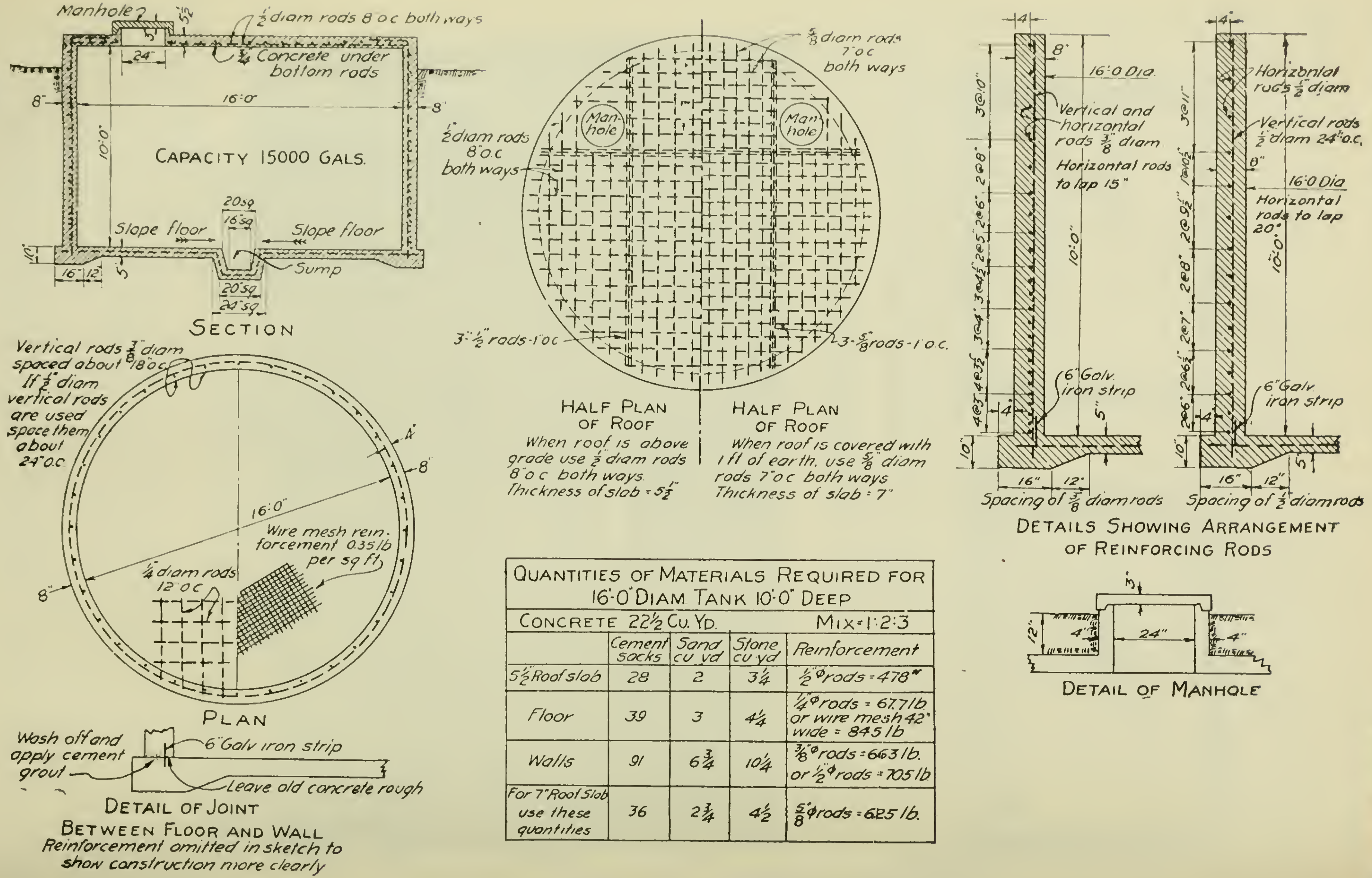
Metal dam seals joint between floor and walls
Concrete mixed 1:2·3

FIG. 5. DESIGN FOR 300,000 GAL. FUEL OIL TANK BUILT IN 1916 FOR CHARLES CITY GAS CO., IOWA.



Note Use 6"-6 mesh, No 6 wire fabric and No 24 crimped galvanized expanded metal

FIG. 6. A TYPE OF CONCRETE-LINED OIL STORAGE RESERVOIR WIDELY USED IN CALIFORNIA FOR STORAGE OF HEAVY OILS.


Manhole
5½"
½" diam rods 8" o c both ways
24"
¾" Concrete under bottom rods
8"
16'-0"
8"
10'-0"
CAPACITY 15000 GALS.
20 sq
16 sq
Slope floor
Slope floor
10"
16"
12
5"
Sump
20" sq
24" sq
SECTION
Vertical rods ⅜" diam spaced about 18" o c
If ½" diam vertical rods are used space them about 24" o c
4"
8"
16'-0"
Wire mesh reinforcement 0.35 lb per sq ft
¼" diam rods 12" o c
8"
PLAN
Wash off and apply cement grout
6" Galv iron strip
Leave old concrete rough
DETAIL OF JOINT
BETWEEN FLOOR AND WALL
Reinforcement omitted in sketch to show construction more clearly
⅝" diam rods 7" o c both ways
½" diam rods 8" o c both ways
Man hole
Man hole
3-½" rods-1' o c
3-⅝" rods-1' o c.
HALF PLAN OF ROOF
When roof is above grade use ½" diam rods 8" o c both ways. Thickness of slab = 5½"
HALF PLAN OF ROOF
When roof is covered with 1 ft of earth, use ⅝" diam rods 7" o c both ways Thickness of slab = 7"
4"
8"
16'-0" Dia.
3@10"
2@8"
2@6" 2@5" 3@4½" 3@4" 4@3½" 4@3"
Vertical and horizontal rods ⅜" diam
Horizontal rods to lap 15"
10'-0"
6" Galv. iron strip
5"
4"
10"
16"
12"
Spacing of ⅜" diam rods
4"
3@11"
1@10½"
2@9½" 2@8" 2@7" 2@6½" 2@6"
Horizontal rods ½" diam
Vertical rods ½" diam 24" o.c.
8"
16'-0" Dia
Horizontal rods to lap 20"
10'-0"
6" Galv. iron strip
4"
10"
16"
12"
5"
Spacing of ½" diam rods
DETAILS SHOWING ARRANGEMENT OF REINFORCING RODS
3"
12"
4"
24"
4"
DETAIL OF MANHOLE

QUANTITIES OF MATERIALS REQUIRED FOR 16'-0" DIAM TANK 10'-0" DEEP

CONCRETE 22½ CU. YD. MIX = 1:2:3

	Cement sacks	Sand cu yd	Stone cu yd	Reinforcement
5½" Roof slab	28	2	3¼	½"φ rods = 478#
Floor	39	3	4¼	¼"φ rods = 67.7 lb or wire mesh 42" wide = 84.5 lb
Walls	91	6¾	10¼	⅜"φ rods = 66.3 lb. or ½"φ rods = 70.5 lb
For 7" Roof Slab use these quantities	36	2¾	4½	⅝"φ rods = 62.5 lb.

FIG. 7. SUGGESTED DESIGN FOR SMALL CONCRETE OIL STORAGE TANK.

metal strip was used to seal the joint, in the same manner as such strips have been used occasionally in the construction of water supply tanks. This has proved a very successful means of preventing any seepage of oil at this point. The mixture used in this case was a 1 : 2 : 3 concrete—that is, 1 cu. ft. of cement, 2 cu. ft. of sand, and 3 cu. ft. of crushed stone or pebbles (see *Fig.* 5).

Mention has been made before that proper design and good workmanship are the chief factors of successful construction. Each concrete tank, unless of relatively small capacity, is a subject for special design, and unless the tank is properly designed to withstand pressure of the stored contents and outside pressure when empty, small cracks might open up and other difficulties arise. This, however, is true with all tanks improperly designed, regardless of the construction materials.

Details of construction must be carefully observed. With proper design, success depends upon properly proportioning, mixing, and placing the concrete and protecting the finished work until properly hardened. The concrete should be so proportioned as to ensure a dense, compact mass, thoroughly mixed to a uniform consistency, preferably in a mechanical batch mixer, and placed in the work as rapidly and uninterruptedly as possible. Continuous operation from start to finish in constructing the floor and walls gives the best results, but when this is not possible arrangements should be made to reduce the joints to a minimum, and adequate precautions taken to bond one day's work to another.

Proper protection of the concrete during hardening is a feature greatly overlooked, with detriment to the finished structure. Concrete must be protected from drying out too rapidly, as this removes the moisture from the cement which is needed for proper hardening. In cold weather the materials should be heated, and work should be protected against freezing for at least forty-eight hours, or until sufficiently hardened to be proof against injury from freezing temperature. In warm weather, of course, the concrete is protected from direct rays of the sun and from drying winds by wetting down the surface from time to time to secure such protection.

All this may sound rather difficult, but in reality it is simple and easily accomplished if the work is done conscientiously.

In cases where underground concrete tanks are used for the storage of lighter products as well as fuel oil and heavy crude oils, additional surface treatment of some sort seems necessary to prevent penetration of the oils. This depends upon the gravity of the oil to be stored. Oils up to 30 gravity can be stored without any special treatment of the surface as previously described. In some cases this is true also of fuel oils of gravity up to 34. However, concrete tanks for the storage of 30 to 36 gravity oils should generally be treated with one or two coats of oil-proofing materials, of which there are a number on the market. Tanks for the storage of gasoline, benzine, etc., should be carefully finished on the inside with a coating intended primarily as a gasoline proofing.

A feature of the investigations relating to reinforced concrete as a solution of the shipping problem is the possibility of concrete oil barges and tankers, and the conclusion arrived at by many engineers studying the subject is that such craft is entirely practicable.

The engineers and naval architects of the Concrete Ship Department of the Emergency Fleet Corporation, organised in December, 1917, have been studying this problem, and plans for such vessels, along with other designs for ordinary cargo carriers, have been completed. The plans call for concrete oil tankers of 7,500 tons cargo carrying capacity or 50,000 barrels of oil, equipped with engines of 2,800 h.p., giving the vessel a speed of 10½ knots.

Five Government yards, with four ways each, have been established for the construction of concrete ships at various points on the South Atlantic, Gulf and Pacific Coasts under the direct supervision of the Concrete Ship Department. Work of building the ways and various structures needed for the plants has been in progress for several months, and beginning of actual construction work on the vessels has just been announced. The 7,500 ton oil tankers will be constructed at the Government yards established in America at various points on the coast ; and several private companies have also taken up the work, and the first concrete barge for carrying oil in bulk was launched July 27th. This was built at the plant of the Fougner Concrete Shipbuilding Company, near New York ; the firm name is similar to that of a Norwegian company whose plant at Moss holds the distinction of having launched and placed in service in 1917 the 200-ton motor ship *Namsenfjord*, the first seagoing ship of reinforced concrete. The hull is a smoothly-finished shell of cement mortar, strengthened by ribs or frames of reinforced concrete at proper intervals, and is partitioned off into various watertight compartments, some to carry the cargo, and others to act as buoyancy tanks. The hold has been given a special finish to ensure its being oil-tight. The barge has a length of 98 ft., beam of 32 ft., and depth of 9 ft. 9 in., and is designed to carry about 350 tons cargo on a draft of 9 ft., the light draft being 3 ft. 10 in.

In Louisiana another plant, operated by James W. Black, a St. Louis engineer and contractor, and a group of men associated with him in the enterprise, is constructing a concrete oil tank barge which is 210 ft. long, 25 ft. in diameter, with a capacity of approximately 10,000 barrels. This vessel is unique in that it is mainly a huge cylinder with cigar-shaped ends, and when fully loaded travels almost completely submerged.

Another vessel for a similar purpose is under construction on the Hudson River, not far from New York, at the plant of the Torcrete Shipbuilding Corporation. The general idea of the craft is much the same, although, instead of being circular in shape, it will doubtless appear more like the whalebacks which have been familiar sights on the Great Lakes for so many years. The vessel is 248 ft. in length with a capacity of 17,000 barrels of crude oil.

MEMORANDA.

Road Resurfacing Experiment.—At Terre Haute, Indiana, we learn from the *Concrete Highway Magazine*, the surface of an old asphaltic road which had been down a number of years having given evidence of rapid disintegration, it was decided to resurface the road with a layer of concrete 3 or 4 in. thick. All holes in the old surface were carefully filled with concrete and levelled off in advance of the actual paving work. Tarvia was then applied to the entire foundation surface, which had first been carefully cleaned and sprinkled with water. It is expected that the complete separation thus produced between the old and new pavements will largely prevent the occurrence of cracks. The mixture specified was 1 part Portland cement, 1½ parts sand, and 2½ parts washed pebbles under 1¼ in. in size. The reinforcement was placed uniformly 2½ in. from the surface, which was finished with roller and belt screeding. Unprotected joints were filled with elastite, which was allowed to project slightly above the finished surface, and curing was accomplished by the ponding method as an ample supply of city water was available. This work is regarded as an experiment, and the results are being watched with great interest, as it is believed that a practical method has been found for utilising what value actually remains in an old pavement, and at the same time putting it in a condition to bear heavy modern traffic.

Submerged Coal Storage.—Some interesting comparative tests of freshly mined coal and of coal which has been stored under water for about a year are given in the *Electrical World*. A concrete pit, 300 ft. long, 100 ft. wide, and 20 ft. deep, to hold 13,000 tons of coal was constructed by the Indianapolis Light Company in 1912. More recently another pit, of reinforced concrete, 145 ft. long, 65 ft. wide, and 32 ft. deep, was built on similar lines, holding 8,000 tons of coal. The company burns 500 tons per day. The total cost of the two pits was £12,000. The results of this under water storage are claimed to have fully met the company's expectations in that it prevented fires and preserved the heating value of the coal. No trouble has been experienced with excessive moisture when burning pit-coal if mine-run is used. The tests showed that coal lost during storage was only 317 B.T.U. out of 12,518 B.T.U. per ton.

CONSOLIDATION OF · GRANULAR MATERIALS.

By JOHN A. DAVENPORT,
A.M.Inst.C.E., etc.

Some time ago I had occasion to make a few preliminary tests on sands, with a view to checking results that had been obtained by calculation ; that search is not yet completed, but a brief account and results of the tests are given, as they may prove of interest.

At the outset it must be emphasised that the test results must be taken as qualitative only, because they were conducted in a practical rather than in a laboratory manner. This statement does not mean that the figures given are unreliable ; but that owing to the fact that certain possible variables were not considered, they are not necessarily absolutely true. The reason will be more clearly seen as the description proceeds.

Object of the Tests.—To get the percentage voids in a mass of uniform granular material packed closely together.

Material Used.—River sand which appeared fairly round. Two sizes were used ; the first passed through a 40-mesh sieve and was retained on a 60 sieve ; and the second passed through a 20 sieve and was retained on a 40 sieve. All the sand was well dried before use.

Apparatus Used.—A tall, narrow glass cylinder of 100 c.cs. capacity, graduated in c.cs., to contain the sand under test ; and a glass burette of 25 c.cs. capacity for measuring the water added to the sand.

Observed Results.—These are given in the table along with the brief remarks that apply to particular tests.

In addition to the brief remarks noted in the table, it is thought advisable to offer the following additional observations :

It is exceedingly difficult, if not impossible, to get a mass of sand into a tall, narrow cylinder without any initial consolidation, and this fact will have some bearing upon the relative values of the tests. The difficulty is clearly shown in the results of experiment number 6, which was made as follows : Sand was filled into the cylinder up to the 100 c.c. line, with as much care as possible to eliminate any initial consolidation ; a cover was placed over the open top, and the cylinder was turned over on its side and erected again quickly, with the result that a consolidation of 1 c.c., or 1 per cent., was obtained ; a repetition of the operation produced a further consolidation of 2 per cent. The variation in final volume, which runs from 86 c.c. to 93½ c.c. for the 40–60 sand and from 87 c.c. to 92 c.c. for the 20–40 sand, experiment 6 being excluded, may be due partly to varying amounts of initial consolidation, and partly to other causes.

CONSOLIDATION OF SAND

Experiment Number.	Nature of Experiment.	Size of Sand	Test Number	Original Volume.	Volume after operation: a	b	c	d	Final Volume	Volume of Water to fill Voids.	Percentage Voids = Vol. Water X100/Final Vol Sand	Remarks.
1	a. Bottom Tapped b Rammed.	40-60	1	100 c.c.s. in all cases.	87½	87	—	—	87	—	—	—
			2		87	87	—	—	87	—	—	Slid out of Cylr. in more or less solid column.
			3		88	88	—	—	88	—	—	ditto
			4		94	93½	—	—	93½	—	—	—
			5		88½	88	—	—	88	—	—	Same as 2.
			6		88	87½	—	—	87½	—	—	ditto.
			Averages		88·8	88½	—	—	88½	—	—	—
		20-40	1		87½	87	—	—	87	—	—	180 Taps.
			2		88	87½	—	—	87½	—	—	do.
			3		88½	88½	—	—	88½	—	—	do.
			4		88	87½	—	—	87½	—	—	do.
			5		91	90½	—	—	90½	—	—	60 Taps - 93 c.c., 120 Taps - 91 c.c. full. 180 Taps - 91 c.c.
			6		91	90	—	—	90	—	—	—
			7		90	89	—	—	89	—	—	—
			8		90	88	—	—	88	—	—	No reduction on further tapping.
			Averages		89¼	88½	—	—	88½	—	—	—
2	a Bottom Tapped b Rammed. c Water Added. d. Bottom Tapped	40-60	1		87	86½	86½	86	86	27 c.cs.	31·4	No change from 86 c.c. from 2-15 p.m. till 5-0 p.m.
		20-40	1		91	90½	90½	90½	90½	32	35·3	180 Taps
			2		92½	91½	91½	91	91	32½	35·7	—
			Averages		91¾	91	91	90¾	90¾	32¼	35·5	—
3	a Bottom Tapped b Rammed. c Water Added d Rammed.	40-60	1		89	89	89	89	89	31	34·8	Had to make Air Hole with long pin.
			2		89	89	89	89	89	32	35·9	ditto
			Averages		89	89	89	89	89	31½	35·4	—
4	a. Water Added b. Bottom Tapped	40-60	1		92	87	—	—	87	31	35·6	Had to make Air Hole.
			2		94½	88½	—	—	88½	31½	35·6	—
			3		94	88	—	—	88	32	36·3	—
			Averages		93½	88	—	—	88	31½	35·8	—
5	a. Side Tapped. b. Rammed. c. Bottom Tapped	40-60	1		88	88	88	—	88	—	—	—
			2		88	88	88	—	88	—	—	—
			Averages		88	88	88	—	88	—	—	—
6	a. Turned on Side and Erected. b. Ditto.	20-40	1		99	97	—	—	97	—	—	This illustrates the difficulty in getting 100 c.cs. of sand into a tall narrow vessel without any initial consolidation.
7	a. Side Tapped. b. Rammed	20-40	1		92	92	—	—	92	—	—	Rammed only lightly
			2		91	91	—	—	91	—	—	ditto
			3		92	92	—	—	92	—	—	ditto
			Averages		91·7	91·7	—	—	91·7	—	—	—
8	a Rammed b Side Tapped c. Rammed	20-40	1		95	90	90	—	90	—	—	—
			2		95	91	91	—	91	—	—	—
			3		96	91	91	—	91	—	—	—
			Averages		95·3	90·7	90·7	—	90·7	—	—	—
9	a. Bottom Tapped b Water Added c. Bottom Tapped	40-60	1		87	87	86½	—	86½	30½	35·3	Had to make Air Hole.

In adding water, great care had to be taken to put it in at one side of the cylinder, to avoid the top of the sand column becoming completely saturated and forming an air lock. Despite the greatest care taken in this respect, the water would sometimes run round the top, instead of down, and in such cases a long pin had to be used to make an air vent. In the case of unconsolidated sand the water has a peculiar effect, when it runs in without forming an air lock. It runs down the side and fills the spaces in the sand at the bottom of the cylinder, up to a height at which the equilibrium is destroyed, and then the saturated sand consolidates, leaving a sandless space between the dry sand and wet sand volumes. Owing to this action, the sand has to be compressed before the final readings are taken.

Indications.—It would be unwise to draw any conclusions from these results; but they appear to indicate two things which may apply to other sizes and shapes than those used, and such are :—

1. It would appear possible to get the maximum consolidation in the dry state.

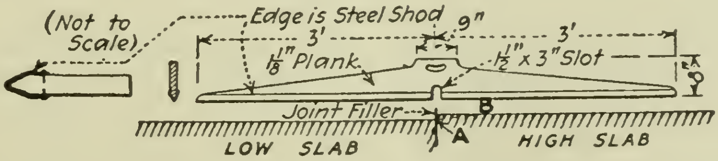
2. It would appear that tapping (or shaking), produces a greater consolidation than does ramming.

If (2) were proved to be universally true, it would probably help, to a great extent, in explaining the discrepancies which occur in the test results of concrete, which appear to be alike in every respect.

MEMORANDA.

Service Connections to Concrete Water Mains.—Metal pipe fittings, such as are kept in stock, can be used in making service-pipe connections to concrete pressure pipe for city distribution lines, by a device recently developed by an American firm. Malleable iron couplings are embedded in the original pipe when cast. The inner end is fitted with a bronze plug inside of a malleable iron bushing. The outside end is fitted with a plug of malleable iron, and the space between them is filled with grease. When everything is in readiness for connections, the outer plug is removed and the plug on the inner end is unscrewed by means of a stem inserted through a T. The plug is then raised to and screwed into a faced bushing at the top of the T. The stem is unscrewed, along with the packing nut and perforated cap, and a solid cap is screwed on the faced bushing at the top. No tapping machines are required, and the excavation need be carried only to the top of the pipe.—*Engineering News-Record.*

Split Straightedge Corrects Joint Humps in Concrete Pavement.—Humps in a concrete pavement due to high slabs at joints are prevented in Wisconsin road work, according to F. M. Balsley, division engineer of the Wisconsin Highway Commission, by the use of the split straightedge shown by the drawing. Owing to the projection of the joint filler above the slabs, the strike board cannot be swept across the joint, and frequently, when it is lifted to start the next slab, exact elevation is not secured. The result is a high slab, as indicated by the drawing. Use of the split float at the joint will bring the edges of the two slabs to a common elevation, as at *A*, in the diagram, but there will still be a hump, as at *B*. The split straightedge, applied as indicated by the diagram, permits the detection of this hump or other irregularities in the planes.



The construction of the straightedge is simple. A $1\frac{1}{8}$ by 8-in. plank is cut as shown, and the edge is bevelled sharp and shod with sheet metal.

A Reinforced Concrete Road in U.S.A.

HOW TO GET THE BEST SURFACE ON A CONCRETE ROAD.

By A. H. HUNTER.*

In spite of the excellent riding qualities of pneumatic tyres, together with all the experience and skill incorporated in the design of body, springs and wheel base of our automobiles, the automobile public is demanding improvement in the surface conditions of our concrete pavements. I do not feel that this is because previously constructed pavements were so decidedly inferior, but rather that with the coming of long stretches of improved surface the novelty of riding on concrete diminishes. The traveller traversing longer units than before becomes more weary and with the accompanying fatigue comes criticism of surface imperfections hitherto unnoticed.

Any road surface, however durable, can scarcely hope to be ultimately successful for use in our through highways unless this wearing surface presents a minimum of jar and vibration. In a properly mixed concrete, such as is used in concrete road work, we have a plastic material susceptible of being moulded into a nearly perfect surface. How closely we are to approach this theoretical plane surface depends upon the care and effort put forth by the workman in finishing. Upon workmanship depends largely the riding quality of surface secured. The impression is not to be gained, however, that proper design is not essential. It would be utter folly to neglect drainage, crown, or both horizontal and vertical alignment, but, fortunately, practice is becoming so standardised that most highway engineers recognise these important features in design. It is most infrequent to find a concrete pavement the poor riding qualities of which may be attributed to poor engineering. If we are to avoid a repetition of past errors, certain construction features must be carefully watched, these features to be considered from their significance as outlined in the specifications as well as their application by the layman.

FORMS MUST BE RIGID.

Too often the layman looks upon the side forms as merely a necessary convenience for holding the concrete, thus losing sight of the fact that the proper grade and alignment of these forms are highly essential if a smooth surface is to result. Not infrequently I have visited construction work and found adjacent form boards out of both grade and line. It is probable that in so far as line is concerned the earth shoulder will later absorb a fair amount of irregularities, but it generally follows that a form setter who does not take enough pride in his work to properly align the boards is equally careless in setting the edge to the proper grade.

In early concrete pavements wood forms were used exclusively. These, when properly used and well taken care of, have given excellent results. When in the hands of careless workmen they soon warp, split and when not properly cleaned cause frequent damage to the edge of the green pavement. When placed to accurate grade and alignment they must be thoroughly staked. Too few stakes is fatal. If these forms are not rigid, waves, bumps and depressions inevitably occur in the completed surface.

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Steel forms are coming into general use. It is probable that specifications in the near future will express a decided preference for them. Many contractors, in an effort to save, purchase too light a weight, with the result that they are soon bent, twisted and unfit for use. In spite of preference for steel forms, they are not to be recommended for short, vertical curves or transverse curves of any character. They are too rigid to adapt themselves to the smooth outline necessary in a properly staked curve.

If we are to improve the surface of our concreted roads appreciably, it becomes necessary for the engineer to see that forms are accurately set to grade and alignment and maintained there. They are the only framework possible in a road. They are as essential as the formwork of a building. They are the guide lines of the pavement.

TEMPLATES NEED CONSTANT WATCHING.

After the concrete is placed within the forms, it should be struck off with a template having a length slightly greater than the width of the pavement. An excess length of possibly 18 in. will suffice for average highway work on pavement 15 to 18 ft. in width, this template to be moved by a combined longitudinal and crosswise motion.

Do not make the common error of cutting the arc of the template to the same dimensions as indicated on the cross-section. It should be cut $\frac{1}{4}$ in. to $\frac{3}{8}$ in. deeper than the theoretical crown ; otherwise the resulting surface will be flat. This correction should vary as the width of the pavement as well as general conditions surrounding the job. The amount of water generally employed would be a factor, for it is apparent that soft, mushy concrete would flatten out more readily than that containing a lesser amount of water. This template should be shod with a steel edge, using countersunk screws. Templates may be made from either one or two boards. If two boards are used, they are held apart some distance by small struts. This style ensures a more uniform bearing on the forms, but is usually heavy, hard to handle and has a tendency to leave bumps or depressions, as the workmen are reluctant to move it back and restrike the surface.

The writer has seen good results obtained by using a heavy, double-edged steel template drawn by a cable, operated by a drum connected with the engine of the mixer.

In moving the template along the forms a slight excess of material must be in advance of the cutting edge at all times. Failure to do this will result in depressions or holes. Do not permit the template to ride on stone or gravel on top of the side-forms. In working on grades even as low as 3 per cent., repeated striking must be done if a smooth surface is to result. The concrete being plastic and of more or less non-uniform water content, will flow down the grade. This flow is not uniform but is given to taking the form of alternate humps and depressions which can only be prevented by repeated and continued striking until initial set takes place. Keeping the amount of water in the mix as low as possible assists materially.

Satisfactory results are obtainable only after pains are taken. The men operating the striker have to have an interest in their work or surface defects will occur. Watch the template ! Check it up every few days, making sure that it has not warped or gone out of shape.

This matter of crown of pavement was forcefully impressed upon me several years ago in connection with the construction of my first concrete road. The template was composed of two striking edges, several inches apart, covered with a plain board on top. At night, after work, it was washed off and placed on the forms behind the mixer. This afforded the night watchman or his visitors, a convenient seat. Continued use for this purpose resulted in a reduction in the crown of pavement by approximately $\frac{3}{4}$ in. This is no large amount, but it is apparent on pavements designed with a minimum of curvature. Frequently too a template, properly designed and cut to the required arc, develops a sag due to its own weight when placed in position on the forms. In general, templates—home-made devices especially—are not to be trusted. Good surfaces may be obtained, but it is only by exercising care and judgment that satisfaction is secured.

EXPANSION JOINTS.

In the first concrete road construction expansion joints were used in varying designs. Many otherwise good pavements had their riding qualities much impaired by these poorly placed joints. Unfortunately, highway engineers have not yet agreed among themselves as to what device is best suited to serve the purpose. Until standard practice develops some uniformity we must expect to have continued experiments with occasional pieces of pavements unsatisfactory.

Generally speaking, any joint or holding device which does not permit the free use of the template is to be condemned. Not that excellent surfaces cannot be secured, but rather that it necessitates special care for the finisher. The elimination of expansion joints altogether, or possible acceptance of blind joints, will do much to improve the riding qualities of our concrete surface.

FINISHING SURFACES AS RECENTLY DEVELOPED.

Naturally enough, concrete pavements were first finished with the same tools as side-walks or building floors. The public approval of a wood float surface led to the general use of a small wood float, 12 in. to 18 in. long, operated by hand. It was possible for the contractor, at small cost, to finish by hand in a most satisfactory manner. It was a tiresome job for the finisher, operating from a cross plank or bridge. Too frequently the work was entrusted to unskilled men, who probably slighted much of the surface, at the same time probably working holes, depressions or flat places at the more accessible portions of the surface. Many excellent surfaces have been obtained in this manner, but substitution of unskilled labour by the contractor in an effort to effect a small saving, together with the drudgery involved, led to development of easier and better methods.

Following the hand float came the easier but unquestionably poorer experiment of placing a small wood float at the end of a long handle. This being operated from sides of the road, permitted the omission of a bridge. It was applicable to narrow pavements, being used with some success on roads up to 12 ft. in width. In general, the surface secured was much inferior to the hand method. The central portions of the pavement were neglected, with the result that too frequent evidence of laitance, dirt or surface defects occurred near the centre.

Engineers had recognised the importance of keeping the quantity of water required in the mix to a minimum, but under working conditions a small excess had been permitted for the reason that concrete of proper consistency was difficult to work. Incidentally, the mixer with spout delivery required an excess of water. Several years back experimenters in the States of Oregon and Michigan perfected mechanical devices for striking, compacting and finishing concrete, but these, while possessing merit, were heavy, costly and unsuited to operation on short, isolated sections.

It is only recently—not farther back than the construction season of 1916—that two simple operations, developed in different parts of this country, have been brought forward that when combined resulted in radical changes in specifications and methods of finishing. I refer to the combined use of roller and belt in finishing concrete surfaces.

To an engineer of Macon, Ga., we are indebted for promoting the use of a small hand roller, some 8 in. in diameter and about 6 ft. long. This was operated transversely across the pavement by a handle. The old adage that " necessity is the mother of invention " certainly holds true to the method developed for smoothing concrete surfaces. It is told that a contractor in Michigan, during the summer of 1916, was inconvenienced by a strike which occurred among his gang after considerable concrete had been placed, struck off but not finished. It seems that in desperation he ripped strips of canvas from his tent, dragged them over the surface in a desperate attempt to place the concrete in a condition satisfactory to the engineer and prevent possible loss. The results were astonishing ; so much so that hand finishing was afterwards dispensed with and a canvas belt substituted.

During the construction season of 1917 the engineering organisation of the State of Illinois, Department of Public Works and Buildings, Division of Highways, used their influence with contractors and secured their co-operation in experiments sufficient to warrant the Department in incorporating this belt-roller finish in the specifications for concrete highways, edition of March, 1918. These specifications, representing the consensus of opinion of the entire engineering organisation, are based upon experience gained throughout the State of Illinois, with different aggregate, different workmen and varying general conditions encountered in actual practice.

HOW TO USE THE ROLLER AND BELT.

The entire operation of finishing specified to consist of three beltings and two rollings, beginning with a belting and alternating until the final belting, the belts to be of canvas or rubber composition, about 2 ft. longer than the width of the pavement. For the first two operations a width of at least 10 in. is recommended. This belt also should be fairly heavy but pliable enough to conform to the crown of the pavement. No irregularities should be permitted in the edges, for these will cause ridges or depressions in the plastic surface. In both the first and second belting the operation should consist of long, transverse strokes combined with a relatively slow, longitudinal movement. After the second rolling the concrete is to be given a final finish, just previous to the initial set of the concrete. The time interval between placing the concrete to final finish is variable, depending somewhat upon the amount of water in the mix but largely on weather conditions. In other words, a highly satisfactory surface can be secured by final belting when the film of surface water has just disappeared. In the last operation a light canvas belt of about 6 to 8 in. in width, used with short, transverse strokes but with a sweeping longitudinal motion, will produce a uniformly gritty surface.

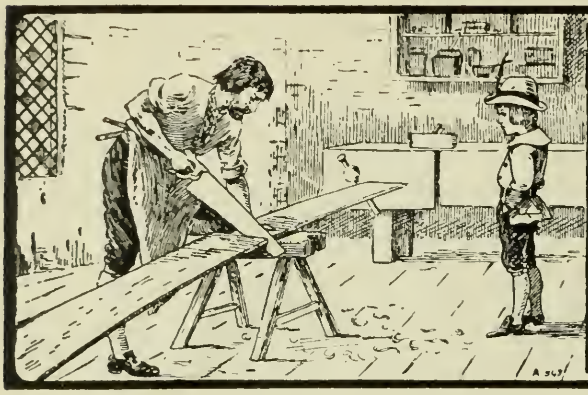
A satisfactory roller may be made with diameter of 8 to 12 in. and a length of 4 to 6 ft., having a total weight of $\frac{3}{4}$ lb. to 1 lb. per linear inch of roller. For roads up to 15 ft. in width it may be operated by a long, light handle. Pavement of greater width requires the use of ropes in place of the handle, operated by a man on either side of the pavement. The first belting following immediately after the strike board is in turn followed by the roller. The roller being advanced to the opposite side from the operator is returned in the same track, then moved forward for half its length and operated as before. The roller is thus advanced along the length of the road, each unit of surface receiving four separate treatments. A trip over in the manner described constitutes a rolling.

The surface should again be belted, and, after a lapse of 15 to 20 minutes, again rolled. This time limit must be somewhat variable and left to the option of the resident engineer. Very wet mixing or cool weather encountered may make it desirable to recommend an additional rolling before final belting. In explanation of the foregoing ideas incorporated in specifications, a word of caution in regard to belting is necessary. The first belting is done to smooth up the surface only, remove slight irregularities and facilitate the removal of the surface water in advance of the roller. In general, belting should be a minimum, for continued working of the surface results in an excess of mortar. Present practice favours the wear coming upon the large aggregate with only enough mortar present to securely bond the stones and prevent voids.

Possibly the foregoing description of finishing may seem complicated, but in reality the physical labour involved is relatively small—much less than required in the old wooden float method. The cost per unit of surface is materially reduced. Surface imperfections are a minimum. The roller eliminates many bumps, by pushing them into the depressions or placing them parallel to the line of traffic where they are unnoticed. Each unit of area receives the same amount of attention, and in the end a uniformly gritty surface is obtained, far surpassing in texture, uniformity and riding qualities the original hand methods.

Roads constructed by roller method have shown an apparent reduction in the transverse cracks. Later uncompleted experiments in laboratory tests reveal the fact that with the rolling and removal of water comes an increase in concrete strength.

In mentioning the recent developments of surface finishing it should not be taken that the roller-belt method represents conditions that cannot be improved upon. For simplicity and low cost of operation it is at present unequalled and its use is to be recommended in the construction of small, widely separated sections of work. It appears probable that future developments in concrete pavements will have largely in mind the proportioning of aggregate so as to produce the greatest possible strength. In connection there will come equipment which by rolling, tamping or otherwise will increase the density and strength at the same time securing all the advantages of a roller-belt finish.



THE "MANCHESTER" SYSTEM OF REINFORCED CONCRETE CONSTRUCTION.

A new system of reinforced concrete construction has lately been invented and patented in Great Britain, in France and in Belgium, by Mr. Charles Henry Heathcote, of Messrs. Chas. Heathcote & Sons, architects and building engineers, Manchester and London, and Mr. Samuel Osborne, constructional and building engineer, of Manchester.

The aim of the inventors has been to economise in material, labour and time, with consequent saving in cost, also with a view to meeting the abnormal conditions which obtain, due to the war, in the countries named, and which will continue in after-war reconstruction.

It is claimed that all disadvantages attendant upon normal methods of reinforced concrete construction are eliminated, whilst all the advantages are preserved and a number of additional advantages introduced, the chief of which are that a structure may be erected under the "Manchester" system in 50 to 60 per cent. of the time, with 15 to 20 per cent. of the timber and with 60 to 70 per cent. of the labour usually necessary in normal construction. The possibility of error in construction is also, it is claimed, reduced to a minimum.

The system comprises pre-casting columns, beams and slabs either on or away from the building site and erecting when matured. A few of the points brought forward by the inventors in favour of their system are :—

(*a*) Standardisation, so far as building construction will permit, is effected.

(*b*) All parts are cast in moulds, which may be used over and over again, with great economy in timber, labour and time.

(*c*) Operations take place chiefly on the ground where the work is more easily accessible, resulting in a further saving in time and labour.

(*d*) Reinforcements are assembled, before being placed in the moulds, in such manner as to prevent the possibility of the bars becoming displaced during the ramming of the concrete.

(*e*) The moulding of parts may be performed under cover and can be carried on in all weathers, resulting in a further saving in time.

(*f*) Erection, when once started, can proceed without intermission with still further economies in time and labour.

(*g*) The various members may, if required, be tested before being placed in the work.

(*h*) Shafting, inserts, wiring tubes, etc., may, with the greatest facility, be introduced into the work in any desired position.

The system is stated to be adaptable to ordinary buildings of one or more storeys, to tank towers, piers, cooling towers, crane gantries, transporter runway supports, pit-head gears—in fact, to any type of construction needing columns, beams or slabs.

Fig. 1 is a view showing the general details of the system, and should be inspected in conjunction with a perusal of the following description :—

Column Foundations.—These are usually of plain concrete. In the top a socket or depression is formed by means of casting into the concrete a " print " made of timber or other suitable material and withdrawn when the concrete has sufficiently set. Into these sockets the lower ends of the first tier of columns are inserted, the sockets being made slightly larger than the columns to allow of a little adjustment for properly spacing the columns to correct centres and for afterwards grouting in.

Columns.—These are preferably octagonal, which is the most suitable shape for this system of construction. The method of reinforcing is the same as for any ordinary octagonal column. Facilities for lifting are provided by casting " eyes " into the column head, which special provision precludes the possibility of damage from ropes or chains which would otherwise take place in lifting. The spreading octagonal column heads provide seating space or bearing for the ends of beams and a socket or depression is formed in the same, similar to that described in connection with the column foundations, to take the lower ends of the columns for the next storey.

Main Beams.—The normal section of these is, roughly speaking, " rectangular," but the ends are moulded to special shape to suit the octagonal heads of columns. At points in the length of beam, as required, pockets are formed in which sit the ends of intermediary secondary beams. In the top of the beams a groove is formed in which, over bearings, rods are laid, such rods having the effect of tying the whole construction together and minimising cracks. The beams are reinforced both top and bottom in such a manner that all stresses to which the member may be subject during transit, handling and erection are properly taken care of. Lifting eyes are provided to assist in handling and erection.

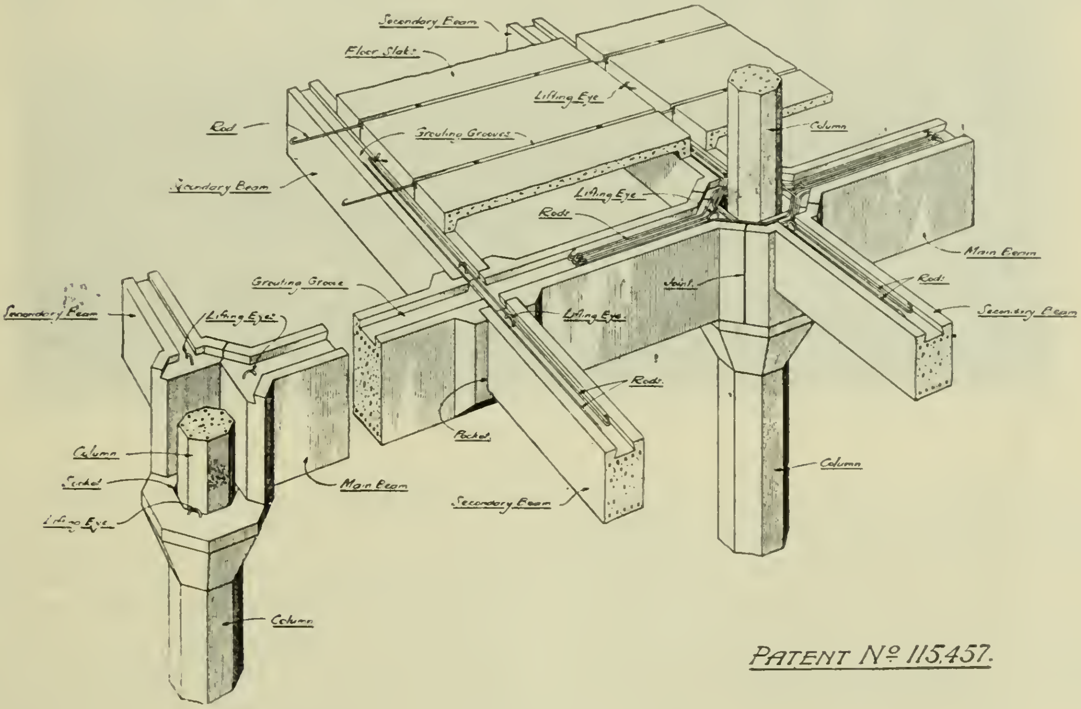


FIG. 1.

Secondary Beams.—Like the main beams these are, roughly speaking, " rectangular " in section, and in the case of the intermediate beams, the ends of which rest in the pockets before described, of uniform shape throughout. Where they rest on columns, however, the ends are of exactly the same shape as the ends of main beams, to suit the octagonal head of column. Reinforcements, facilities for lifting, etc., are generally as for the main beams.

Floor and Roof Slabs.—These are made in convenient sizes for handling and erection. The ends of slabs rest on the secondary beams and the sides butt closely together. To prevent any single slab, or a number of slabs, deflecting unduly, leaving the others standing, grooves are formed in the sides of the slabs which, when filled with grout, form an effective " key " between one slab and another. The edges of slabs are rebated so that when two slabs are lying together a groove is formed into which, over bearings, rods are introduced for exactly the same purpose as described in connection with the main beams. The slabs are reinforced in such a manner that transit, handling and lifting stresses are properly provided for. Lifting eyes here again give every facility for handling and erection.

Erection.—The concrete foundations are first of all properly and accurately levelled up, after which the first-storey columns are placed in position and propped. When columns are accurately spaced and plumb, or at any other convenient time, the bases are run in with cement grout.

Main and secondary beams for the floor above are now lifted and placed in position, the ends of same being bedded in cement and the joints between the ends of the beams being pointed up in cement.

The floor slabs are now lifted and placed in position, their ends being bedded in cement. Afterwards the second-storey columns are erected, correct spacing and plumbing being carefully performed.

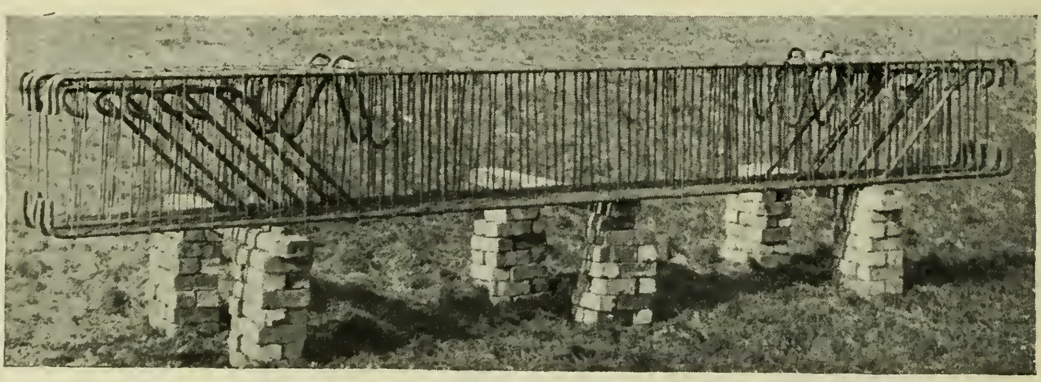


FIG. 2.

If the floor finish is to be of boards, wood blocks, or anything of a similar nature, the next stage of the work is as follows :—

All rods are laid over bearings of the main beams, secondary beams and slabs, in the grooves provided for the purpose, and cement grout or fine concrete as necessary poured in up to the level of the top of the floor slabs. This additional concrete or grout, in conjunction with the rods now embedded in it, has the effect of tying the various members together and results in a perfectly monolithic piece of construction.

In the event, however, of the floor finish being of granite and cement, the following method of procedure is adopted :—

Rods are laid only over the bearings of the main and secondary beams and grout or fine concrete as required is poured in up to the level of the bottom of the grooves in the slabs. The slab rods are not laid until all is ready for putting on the floor finish, when they are placed in position and embedded in the floor finish itself, which fills up the slab grooves and is, by such means, provided with an excellent " key."

The above course of procedure is followed for each of the remaining floors, and also generally for the roof, which may be proofed with asphalte, prepared roofing, or in any other manner, exactly the same as in normal construction.

Full importance should be realised of the fact that, in erection, no "*in situ*" formwork whatever is required in connection with this system. The whole of the work, if ordered in sufficient time, may be at hand as soon as the site is cleaned and foundations installed. Given the area of the building, the number of storeys, the heights of floors, the floor loadings and the centres of columns, the work can be proceeded with immediately. For speedy after-war reconstruction the inventors claim this is a most important point, as, by this means, the parts may be prepared at any convenient centre under "factory" conditions and distributed to various sites for erection. For example, it would be quite possible to prepare the parts in Great Britain and transport the same, say, to France and Belgium, for use in rebuilding those devastated areas destroyed by the war.

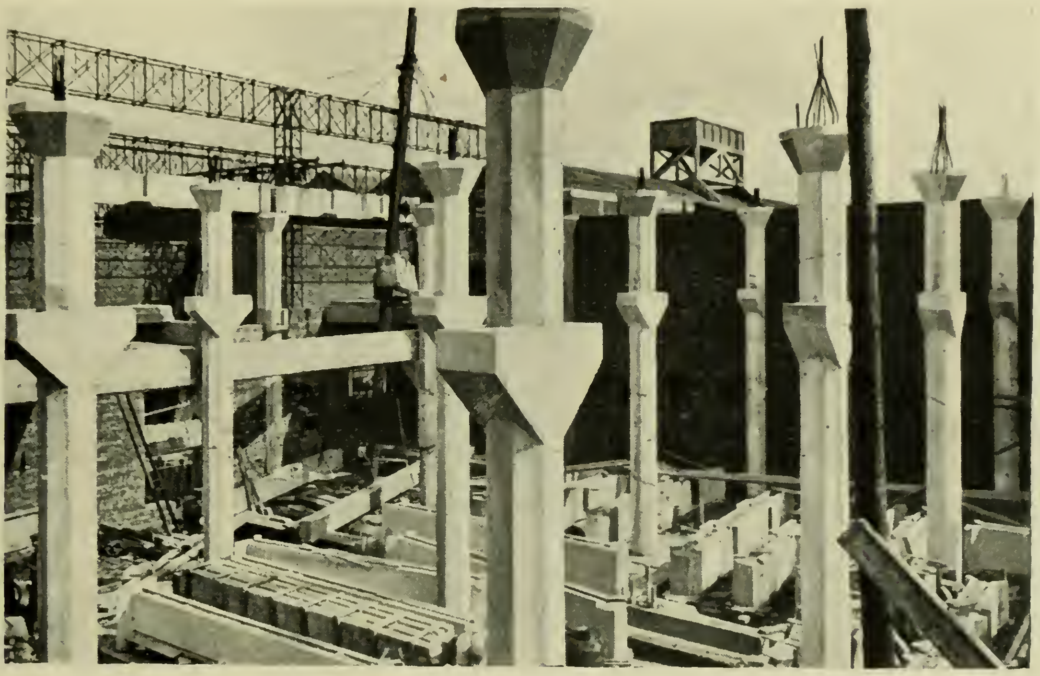


FIG. 3.

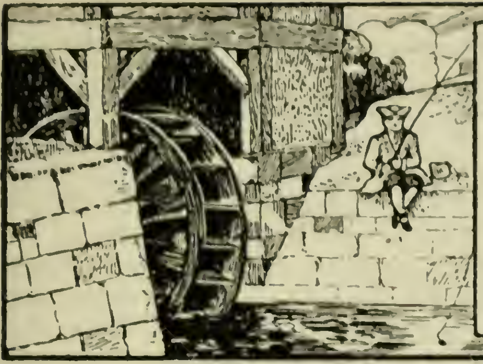
As the question of the adhesion of new to old concrete is a doubtful point, especially in the case of the old concrete being dirty, special precautions have been taken to prevent the old and new concrete parting company by making the grooves in the various members wider at the bottom than at the top.

Fig. 2 is a photograph showing how reinforcements are assembled before being placed into the moulds. The rigid nature of the construction is apparent, as also is the possibility of verifying the accuracy of the work. The "human element" is, the inventors claim, very little to be feared in this system of construction, every detail having been devised with a view to its entire elimination.

Fig. 3 is a photograph of a building in course of erection, the contract having been carried out by the Fram Reinforced Concrete Co., Ltd., of 37, Princess Street, Manchester, who are the sole licensees for the system. The columns are here shown erected, whilst on the ground are to be seen main and secondary beams in various stages of maturity before erection.

As an instance of how the adoption of this system is instrumental in saving time the inventors state an interesting fact in connection with this contract. From the first delivery of steel rods, which were found to be for beams and slabs, until the delivery of the column rods, ten clear weeks elapsed, during which time the work, if normal construction had been adopted, would have been standing. No time was lost, however, as beams and slabs were proceeded with. This saving in time is altogether apart from the further saving, due to the beams and slabs having been ready for simply lifting into position as soon as the columns were erected.

Instead of the usual four to six weeks for "striking" formwork, the moulds in this system are removed in anything up to three days, according to the size of the piece cast, and, if the work is carried out in the open air, according to the conditions of the weather, so that, as the moulds are immediately ready for re-use, the great saving in time at this stage of the work is at once apparent. Whilst the concrete is still "green" it is trowelled, resulting in a surface finish such as is very seldom seen in any form of concrete construction.



THE HOUSING PROBLEM.

Extract from the Report issued by Sir J. Tudor Walter's Committee, appointed by the Local Government Board to consider Questions of Building Construction in connection with the Provision of Dwellings for the Working Classes.

Continued from March Issue.—ED.

(Concluded.)

CARPENTER AND JOINER.

255. We consider that, in building immediately after the war, every precaution should be taken to guard against dry-rot, as the conditions of the timber trade and the necessity to use all kinds of timber are likely to involve increased danger of infection, the results of which can only be guarded against by carefully avoiding the conditions which promote the development of the disease. These two conditions are dampness and stagnation of air, which are particularly dangerous when both are present; ventilation should be provided around timber wherever possible, and be enough to secure a complete circulation of the air. Where wood-joist floors are used on a portion of the ground-floor storey, air-bricks on one side are not sufficient. If solid concrete floors are used in rooms adjacent to those fitted with floors formed with wooden joists, it is desirable to lay field drain-pipes in or under the former, connected with air gratings on the outside walls so as to secure a thorough current of air and thus avoid corners under the wooden floor where the air might become stagnant. Plates built into walls should be used as little as possible, and when so used should be treated with some preservative. It would be better to use a course of tiles, slates or concrete strips to form a level bed for joists rather than build in wooden plates, particularly under the ground-floor joists. The ends of joists inserted in walls are better built round with a dry joint so that a little air may circulate, instead of being surrounded by a mortar joint. Some ventilation should also be provided in roof spaces, particularly where the roofs are boarded and felted. Proper attention to such precautions may avoid the heavy outlay which frequently results when dry-rot has developed.

256. Further points which are being investigated in connection with economy in the use of timber relate to the relative strength of home-grown timbers as compared with imported, and of American as compared with Baltic. It has been represented to us, in justification for the different standard of scantlings adopted in America and Canada as compared with those adopted in the Baltic trade, that the former timber being somewhat stronger, a smaller scantling can be used where it is substituted for Baltic timber. A claim of this sort, put forward in general terms, does not carry conviction, and questions of grade of timber and of cost would arise before an absolute statement could be made in regard to possible economies through more extensive use of American or Canadian timbers. At the same time, full information regarding this question should be available for the use of architects and builders in some such form as would enable the most economical sections to be specified for particular purposes, or permit the use of specified alternative woods under the terms of a building contract.

257. We have had under consideration the question of compiling tables which would set forth the relative strengths and qualities of the various timbers now commonly used in building. We are advised, however, that the existing information on the subject displays such differences in the results obtained by various experimenters in different countries that such tables would be of little practical value. We have, therefore represented to the Department of Scientific and Industrial Research the urgent need of an investigation under standard conditions of the relative qualities and properties of Baltic, Canadian, and American timbers in order that appropriate and reliable information may be placed at the disposal of British consumers of timber at the earliest possible date.

258. In further connection with the economical use of foreign timbers, it has been impressed upon us that, owing to the lack of an appropriate organisation for standardising the qualities of such varieties as are from time to time placed upon the market, possibilities of substantial development of our resources in imported timbers are lost. It is natural that an architect should hesitate to specify or to allow the use of unfamiliar timbers, information regarding which can only be supplied to him by interested parties. Many varieties of timber which are now in popular use and which furnish important additions to the resources of the architect and builder have only secured a firm hold on the British timber market after long periods of doubt and hesitation. The desirability of prompt recognition of the merits of any new varieties which may in the future be introduced points to the need for a testing and standardising organisation in this country.

It is pointed out that with the end of the war new resources in timber are likely to be available. The Panama Canal now facilitates the import of supplies of building timber from California and British Columbia. During the war possibilities have also been revealed of substantial supplies from Siberia, etc.

259. We feel that very considerable economies in the prime cost of imported timbers will be secured if architects and builders generally will exercise increased interest in the nature of the standardisation which can be most economically effected in the case of imported timbers. Such an excessive degree of standardisation as has been brought about in the case of, say, Quebec spruce, and, in a lesser degree, of Baltic timbers generally does not tend to facilitate economical marketing of imported timber, and, indeed, as has been pointed out to us, has proved to be a serious bar to the introduction of many valuable varieties of American timbers. A more intimate association between architects as a body and timber agents and importers would doubtless result in such modifications in current demands for standardised timber as would go far towards effecting useful economies in the import and use of Colonial and foreign timbers.

260. On several occasions it has been urged upon us that the new and more scientific use of timber adopted in aeroplane construction to secure the maximum of strength with the minimum of material should offer suggestions for economising timber in cottage construction. When considering the durability of timber over the life of a well-built cottage, a certain amount of bulk of material and simplicity of form would probably be necessary for reasons entirely absent in aeroplane construction; also with the prices of timber which ruled before the war, it was more economical to add slightly to the size of the timbers than to increase the labour involved in structural work. Nevertheless, we think there is sufficient truth in the suggestion to warrant more careful consideration as to the manner of using timber for floors and roofs. Probably a greater use of light strutting or dwangs between joists would enable a rigid floor to be secured with somewhat less material. In roof construction also, provided that care is taken to secure an adequate tie at the foot of the spars, lighter spars and rafters could often be safely used. The high price of timber likely to prevail after the war would certainly justify greater care in the design and erection of the structure so as to avoid waste of material, and would also justify a little more labour in careful strutting and tying with light spars with a view to economy of material.

It must be borne in mind, however, that timber which is used for structural work has not only to be strong enough to carry the load which will be placed upon it, but to do so without assuming a permanent set; such a permanent set is more liable to occur in timber not completely seasoned, and in such timber a considerable margin of strength is required to secure the maintenance of form in long lengths, so that the economy which might result from the more careful tying and strutting with light timbers would in some cases save a fairly considerable bulk of timber in the beams.

261. In the use of timber excessive standardisation of certain scantlings or lengths tends to exhaust the supply without any compensating advantage in economy of production ; in times of scarcity of timber, therefore, it will be wise for architects and others supervising the erection of buildings not to adopt a too rigid specification as to sizes, but to be willing to accept alternative scantlings of sufficient strength for the positions for which they are intended ; joists slightly thinner and spaced nearer together, for example, may be employed as the equivalent to those rather thicker and spaced farther apart. In regard to doors, sashes, frames, etc., a change of $\frac{1}{2}$ in. in the size of the members might enable them to be cut economically from 8 in. scantlings instead of from 9 in. The total quantity of timber both for carcassing and for joinery which will be required in connection with the housing programme is so large that in fixing standard sections in order to secure the economy of large-scale production no loss of this economy would result from having a sufficient number of alternative standard sections to enable different sizes of imported timber to be conveniently converted with the minimum of waste.

262. In regard to standardisation of joinery, the evidence varied as to the number of articles which would be required to give the maximum economy due to standardisation. Some witnesses mentioned 1,000 articles in this connection, others gave a much higher figure ; but the latter were also thinking of the full employment of plant and of organisation on a large scale not dependent entirely on exact standardisation. All the experts agreed that considerable economy was to be effected by a sufficient standardisation and also by careful consideration of the details of each article in relation to the process of manufacture ; for example, moulds and shapes should be selected which could all be cut on a four-cutter machine without spindle work, and articles needing machining on one edge only should be run through the machine double width and afterwards cut down the centre.

263. Further, it is important, in designing joinery details so as to avoid waste of timber, that the parts should all be of sizes that can be cut out of standard imported scantlings allowing for the necessary saw cuts and waste in planing. In the past certain architects have been in the habit of specifying even sizes, such as 2 in. for the door, and requiring that the door should finish 2 in. thick. In the trade the normal 2 in. door is cut from 2 in. imported material, and having been planed on two sides will be about $1\frac{7}{8}$ in. thick. If it is insisted that the door must finish 2 in. thick it may be necessary to cut it from $2\frac{1}{2}$ in. timber, which involves waste ; manufacturers recommend, therefore, that the nominal sizes of the timber from which the members are cut should be given and that an allowance for cutting and planing should be made in the finished article. In the case of windows, for example, the frame should be cut from 3 in. × 4 in. material, sashes from $1\frac{3}{4}$ in. × 2 in. and the bars from $1\frac{3}{4}$ in. × 1 in. Manufacturers strongly recommend that a standard-sized pane should be adopted in each scheme and all windows made as a multiple of this unit ; all machining could be done to templates and stops ; a standard size of glass would fit all openings, and there would be a greater simplicity in the setting out of all heights and widths of openings not only in the workshop but also on the actual building job.

264. In comparing the different types of window, evidence appears to show that in exposed situations the double hung sash is more to be relied on to keep out driving rain, particularly if it has a deep bottom rail ; moreover, the sash has advantages in connection with ventilation, in that it is easy to open at the top, or with a deep bottom rail to open for ventilation at the meeting rails. On the other hand, the sash is more expensive than the casement of equivalent quality both in first cost and upkeep, the cords and fasteners are likely to give trouble, and the frame being constructed in the form of a boxing of light wood is more liable to perish than the solid frames used for casements. Although the sash can be relied on to keep out the wet, it is more liable to rattle in windy weather and can only be cleaned by a person sitting on the sill, unless the construction is elaborated so as to allow the window to open inwards or swivel for cleaning purposes. Where casements are used, top ventilation can be secured by the use of a transom or a wide split rail, allowing the upper portion to be hung at the top and open outwards; in this way ventilation is secured and the wet at the same time excluded; where a transom is used folding lights can be adopted in the lower half and the mullion can be omitted. Another argument in favour of the casement is that it lends itself more readily to the adoption of different sizes; it can be built up one, two, three or four lights in width, and it can be made with any number of panes to suit small apartments like larders, lavatories, etc., where a large sash window is cumbersome. The sash window, on the other hand, to produce a good effect, requires rather careful aligning and orderly arrangement, which is often not easy to attain in cottage elevations without too great a sacrifice of internal needs.

265. Another type of window which is simple and inexpensive is that known as the "Yorkshire Slide," in which the lights slide horizontally instead of vertically; balance-weights and cords are not required; the window is fairly weather-proof, and owing to the form of fastening does not usually rattle. It does not, however, provide for ventilation in wet or rough weather. Such a window could be made with a transom, and a light over the transom hung at the top to open outwards for ventilation purposes. This would add somewhat to the cost, because it would be difficult to make the sections of the frame above and below the transom alike. If both sashes are made to slide, the window can readily be cleaned from inside, and in combination with a transom and fanlight it would form a useful alternative type. The beading on which the sash slides should be of oak or other durable hard wood, and care should be taken, either by stopping the end of the outer beading, or by providing occasional slots under the bead, to avoid lodgment for water. Several types of metal bars and rollers are made which reduce the friction and facilitate the sliding of these sashes.

266. Whatever type of window is adopted for the upper storeys, the facility for cleaning the window panes from inside the room should be considered; if hung sashes are used, the type that will swing for cleaning is to be preferred; if casements are adopted, the arrangement of the opening lights should be such that each section of the window can readily be cleaned from the adjacent opening. Where this is not practicable for all the sections, it may be necessary to adopt special hinges for one of the lights which will allow this light to be swung so that the hand may pass through on the hinge side of the window for cleaning the adjacent light.

267. In considering the details of any standard frames, sashes, or lights, the type of standard fitting proposed to be used must be taken into account, and the windows should be so designed as to give the widest and firmest fixing-space for all fittings which the size of the material adopted will allow. Fittings should, if possible, be fixed with more than two screws and these not all in a straight line. If only two screws can be used they should be of extra strength and length. Mouldings or splays on that part of the frame or sash where the fitting is to rest should be avoided, since they involve cutting-away or sinking for the fittings and, therefore, add to the cost of fixing.

268. The sill, owing to its position, is liable to perish sooner than other parts of the frame. In ordinary circumstances, the extra cost of providing oak sills to window-frames should be regarded as an economy.

269. It was suggested with a view to economy that hinges should all be fixed in the shop to standard gauges; sashes would be interchangeable and could be glazed in the shop and hung when the building was ready; this would avoid considerable wear and tear and breakages to the sashes during building operations.

270. With regard to doors, the standard sizes ordinarily made in the trade are:—

2 ft. 4 in. × 6 ft. 4 in.	2 ft. 8 in. × 6 ft. 8 in.
2 ft. 6 in. × 6 ft. 6 in.	2 ft. 10 in. × 6 ft. 10 in.

There appears to be no logical justification for varying the height and width of each size by 2 in., except that the dimensions are easy to remember. The arrangement does not secure doors of the same proportion, and is open to the objection that several heights are introduced into one room or passage. We recommend that for cottage use doors of different widths should all be made to one or two standard heights, and that 6 ft. 4 in. and 6 ft. 6 in. would be suitable heights for internal use; this would fix a convenient level for lintels, picture rail, etc. The doors should be made so as to utilise material 9 in. and 8 in. in width and 2 in., $1\frac{3}{4}$ in. and $1\frac{1}{2}$ in. in thickness; styles, mountings and top rail being cut in duplicate out of standard widths, while the lock and bottom rails remain the full standard width subject to the allowances as before explained for sawing and planing; such doors could be finished with a simple ovolo mould on the solid, or with a splay on the upper horizontal edges to throw off the dust, and could then be entirely cut on the machine and could be manufactured in large quantities. For a small additional expenditure per door, five and six-panel doors in place of four-panel could be adopted, and would enable more pleasing proportions to be secured for a very nominal extra cost with standard patterns.

271. In the case of standardised doors, the widths of the styles, the arrangements of the rails, mortices, etc., must be considered in conjunction with standardised locks, latches, etc. Where thumb latches are used for panel doors, the latch rail should be placed at a higher level to carry the latch; otherwise the latch must be specially made to fit the style; this shortens the latch, reduces the leverage, and makes the latch both difficult and jerky in its working. The use of standard templates in connection with the fixing of hinges for door frames would lead to economy in erection on the job.

272. Considerations similar to those to which reference has been made in regard to economy in the manufacture of doors apply to cupboard fronts and other fittings, while the mouldings, skirtings, and picture rails should all be designed and cut economically from standard sizes with the minimum of waste. If mouldings are designed economically two mouldings may often be secured out of a rectangular piece of timber little larger than the outside dimensions of the moulding, by splitting it diagonally. All such economies must, of course, be considered and treated for what they are worth. There may be occasions on which a bolder moulding which could not be so cut would be very well worth the extra cost of the timber involved.

Where wooden floors are used, a simple splayed fillet secured to the floor forms an effective adjunct to the skirting: if the joists shrink, the fillet slides down the face of the skirting with the floor and the objectionable space between the bottom of skirting and the floor, which is caused by shrinkage of the joists when the skirting is fixed to the wall, is thus avoided. When composition floors are used, it is desirable to run the skirting in the same material as the floor.

273. In reference to the construction of cupboards, the following points were brought to our notice:—

1. That cupboards generally should be carried up to the ceiling so as not to leave a space on the top where dust and discarded articles are liable to accumulate.
2. That dressers and shelves intended to take pots and other utensils should be provided with doors.
3. That in the construction of cupboards and shelves it is desirable to avoid anything that would create crevices for insects or vermin, or places difficult to keep clean.

The shelves may be set $\frac{1}{2}$ in. from the wall, and if the frames could be secured to grooved concrete jambs to which the plaster could thoroughly adhere, many objectionable crevices due to the shrinkage of the wood and to the fact that plaster or mortar and wood do not adhere together would be avoided. As already mentioned, experiments are being made with various forms of concrete, and it is hoped that some composition will be found which will give a suitable key for plaster, which will be capable of taking nails and affording convenient attachment for cupboard fronts and other similar fittings and which, at the same time, will be sufficiently strong for the purpose.

274. In regard to staircases, some advantage would be gained if one or two standards were fixed for the rise and the width of the tread, also the width between the walls might be standardised to 3 ft.; a standard height of 8 ft. 9 in. from floor to floor would give 14 risers of $7\frac{1}{2}$ in., which would afford a convenient standard, and each tread should be wide enough to provide a 9 in. travel.

A handrail should be provided to the stairs. Where winders are used, it is desirable to place the handrail at the outer or wide end of the winder steps. A simple batten out of $1\frac{1}{4}$ in. stuff, rounded on the top edge and fixed securely with blocks about $1\frac{1}{4}$ in. from the wall, is effective and takes up little space.

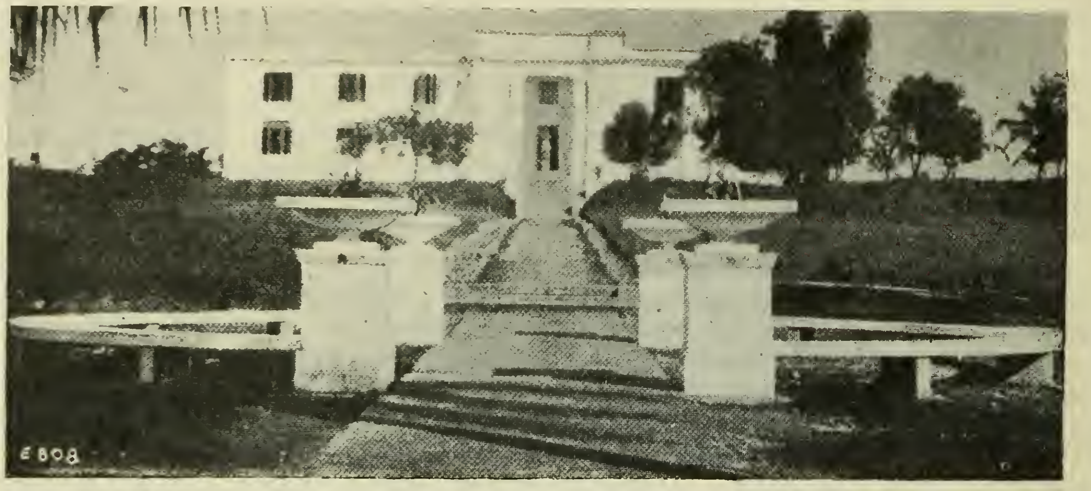


Fig. 1. Ornamental Concrete Work in Grounds of the University of Porto Rico Rio Piedras.

ORNAMENTAL CONCRETE SEATS AND COLUMNS FACED WITH WHITE MIXTURES.

Many of our readers will probably be interested in the following particulars regarding the application of concrete to ornamental work in the garden and on the estate. The fully illustrated article on this work appeared in the "Industrial Arts Magazine," Milwaukee, written by Professor Hjorth, and our present abstract is taken from "Concrete," U.S.A.—ED.

In the centre of the campus of the University of Porto Rico, Rio Piedras, P.R., several paths converged into an elliptical plot. In this ellipse it was decided to build two half-circles of benches useful and convenient and at the same time suitable and conforming to the surroundings. A central path divides the ellipse into two equal parts and a circular path follows its circumference and is joined by four other paths. It was decided to construct one half-circle of benches on each side of this central path so that the two columns in which the half-circle terminated would be in line with the path and exactly opposite the two columns of the other semicircular bench.

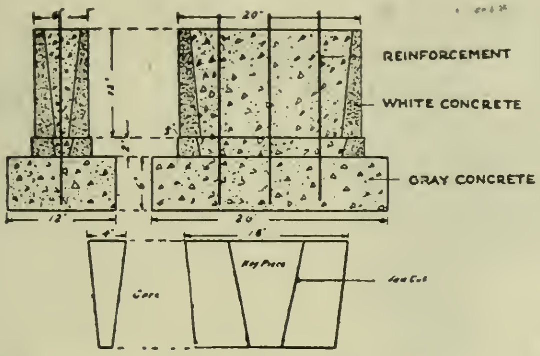
The benches were to be of white cement and marble dust and decorated with inlaid faience and gold tiles. But as white cement is twice as expensive as the ordinary kind, and marble dust costs $1.50 per 100 lb., or about eighteen times as much as sand, economy was necessary. It was decided, therefore, to make a shell, so to speak, of the white concrete and fill this with ordinary concrete. This made the problem far more difficult, but also much more interesting and instructive.

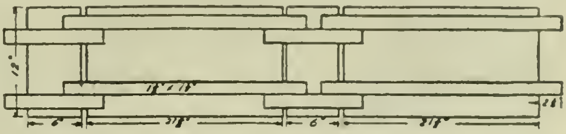
Form construction is shown in *Fig.* 2, the footings being constructed entirely of ordinary concrete, designated here as grey concrete, so as to distinguish it from the white. The forms were made of four pieces of wood nailed together like the sides of a box. No bottom was put in, but the forms simply placed on a concrete floor and filled. A heavy piece of paper was placed on the floor, so that the fresh concrete should not adhere to it. While still wet, three $\frac{3}{8}$-in. bars were placed in these footings, to project 16 in. above.

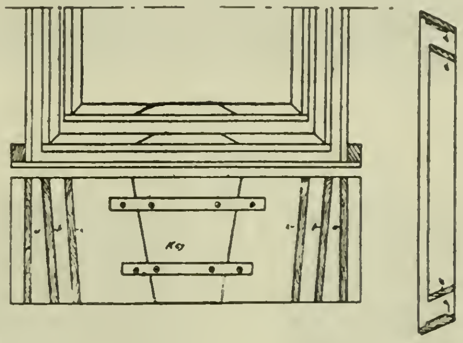
The supports consisted of two parts. The lower part was merely a slab of white concrete, 2 in. thick, with a rectangular opening through the centre.

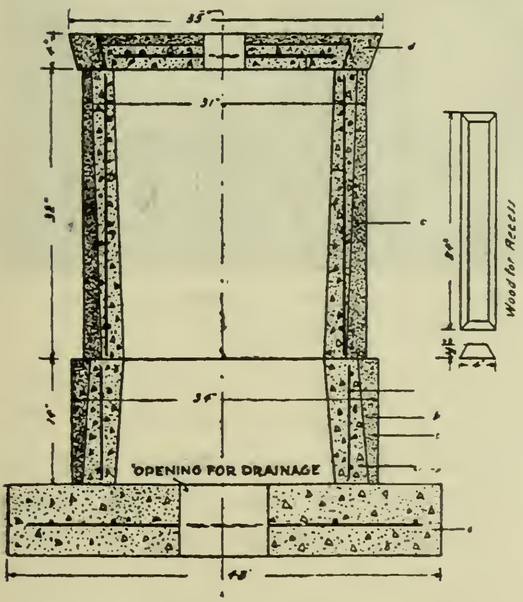
The form for this is shown in *Fig.* 3. It is simply a box without a lid, and the rectangular opening in the centre is formed by a piece of wood. This was bevelled slightly on all sides (draft), so as to come out easily when the concrete had hardened. A heavy piece of galvanised wire was used for the reinforcement of these slabs.

The upper part of the supports was made somewhat similar to a square flower pot. The forms are shown in *Fig.* 3. The outside form was made like a box. Three-quarter-in. boards, 12 in. long, were used. It is important that the boards be of exactly the same thickness and well jointed, but they need not be hand-planed. Before the box was put together provision had to be made for the recesses in the front part of the supports to be inlaid with tiles. This was done by nailing on strips and squares of wood of the right dimensions and placing them in the proper relationship. They were given plenty of draft. The core was made to the dimensions given in *Fig.* 2. It was then cut into three pieces as indicated. These three pieces were held together by a strip of wood nailed to the top, and also to the sides of the box, and they were located in the centre of the box by means of dowels in the bottom board. Both the box and the core were well greased before the concrete was poured, using automobile grease thinned with kerosene to the consistency of thick glue.









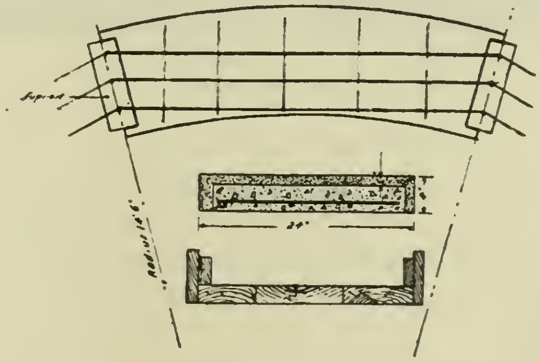


Fig. 2. Construction of Seat Supports.
Fig. 5. Construction of Terminal Columns.

Fig. 4.
Fig. 7. Double Core Construction for Columns.
Fig. 8. Plan of and Moulds for Seats.

When the concrete had dried about twenty-four hours the bottom was removed and the middle piece (the key) of the core driven out; the two other pieces then came out easily.

After the ten supports had been cast and the surfaces finished the preparation of the ground had been so far completed that the work of erection could be started. The supports were placed in such a way that they formed angles of 30° with each other and angles of respectively 30°, 60°, and 90° with the central path. A hole approximately equal in depth to the thickness of the footings was then dug for each footing, after which they were placed in the exact position level and exactly at the same height. In order to keep them firmly in place the holes around the footings were filled with concrete. The base and the upper part of the supports (*Fig.* 3) were then slipped over the three reinforcement irons, placed in the correct position by means of the transit and the steel tape, and filled with ordinary concrete, making them solid and firm.

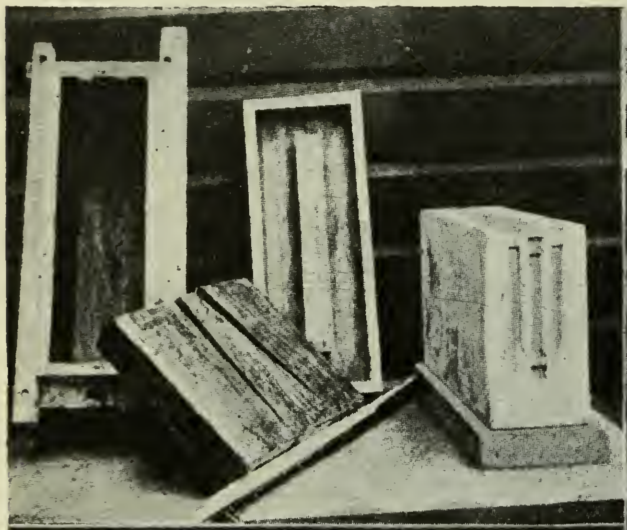


Fig. 3. Moulds and Core for Seat Supports.

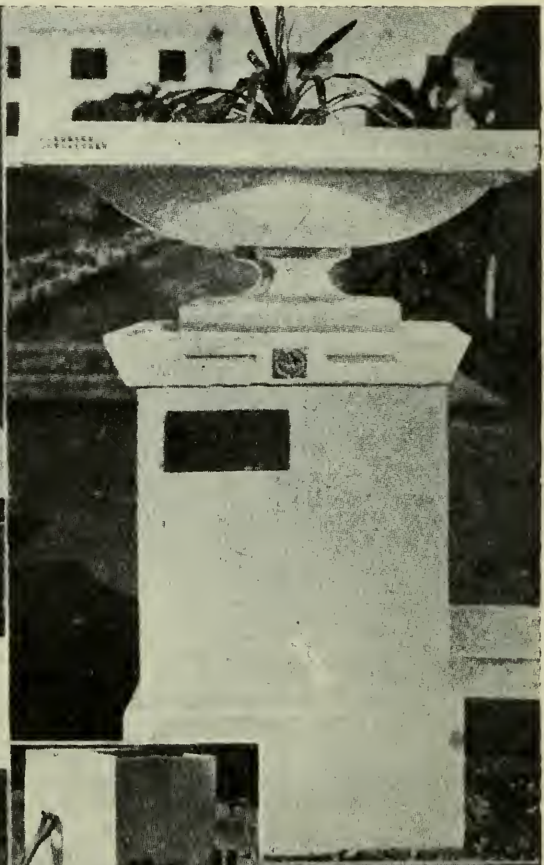


Fig. 6. Completed Column Surmounted by Urn.

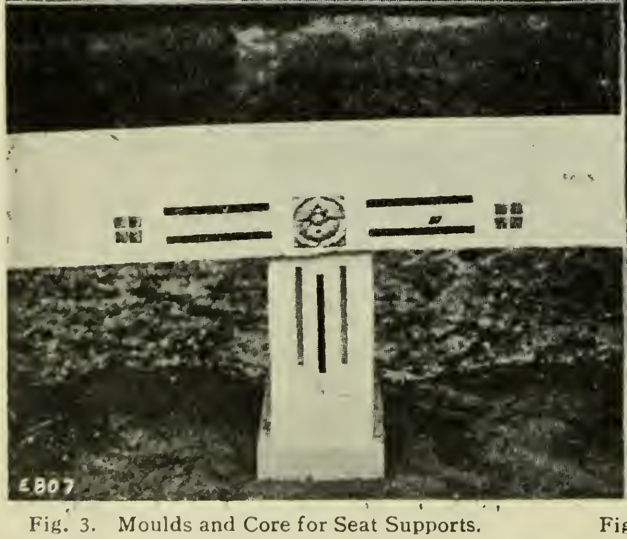


Fig. 10. Section of Seat and Support.

Fig. 9. Seat under Construction.

As will be seen in *Figs.* 5 and 6, each of the four columns was built up of four parts—viz., the footing, the base, the body, and the top. The place for the footings was first located and excavated. The mould was then placed in the correct position level and at the correct height, the same as the footings for the supports. In order to provide drainage for plants an opening was made in the centre of the footings about 8 in. by 8 in. This form was filled with ordinary concrete reinforced as shown, carefully tamped and levelled.

The bases were made in the shop, the method being similar to that used in making the supports. First a thin shell of white concrete had to be made, and this had to be strengthened by filling with ordinary concrete. But as it was found undesirable to make the base solid on account of weight and cost of material, the problem was finally solved in the following manner: The forms were made in the same manner as those for the supports, but with two cores, the larger one for the white concrete and the smaller one for the grey concrete (*Fig.* 7). A smooth concrete floor was again used instead of a bottom of wood, the core *b* placed in the form, and the white concrete poured. Four hours or five hours afterwards the core *b* was carefully removed and the core *c* placed in position. The reinforcement was then placed between the white concrete and the core *c*, and the grey concrete poured. The interval between the casting of the two kinds of concrete was made as short as possible, so as to insure a perfect bond. After the grey concrete had hardened about twenty-four hours the core and form were removed. In making such cores two opposite sides should be constructed with a key piece as shown in *Fig.* 7, which may easily be removed, thereby facilitating the removal of the entire core. This should always be done before the outside is removed, so as to prevent cracking the concrete by any undue amount of strain necessary for removing the core.

After completion the four bases were placed in position on the foundations, but the reverse of the way in which they were cast, so that the end having the thickest layer of white concrete was placed face up (*Fig.* 5). As the body, *c*, would be too heavy to transport, the forms were placed directly on the base and the concrete to fill them brought in wheelbarrows. The forms were made with two cores exactly in the same manner as for the base, with the exception of the recess, which had to be made in one of the sides to allow for joining the seat to the columns.

The top, *d*, was also made of both white and grey concrete, but in this case the grey concrete was cast first in form *a* (*Fig.* 7). The outer form had to be provided with bevelled strips of wood to allow for the inlay. The joints were all "hopper." A hole for the drainage was provided very easily by placing a 1-gal. paint can in the centre before the concrete was cast.

Next the construction of the two seats was undertaken. In order to get a full-size drawing of these to work from, an angle of 30° was laid out on the floor of the shop with the aid of the transit. The length of the radii was measured and a full-size detail of a section of the bench between two supports laid out from *Fig.* 8. A full-size detail of the section between a column and a support was obtained in the same way. Templates of 1-in. boards were then made to fit these outlines, and from these templates the bottom of the forms were cut. These, however, were made of 2-in. planks securely tied together with cross-pieces nailed to the under side, as they would support considerable weight, the seat being 4 in. thick and 24 in. wide. They were fitted in place, carefully levelled, and securely braced.

The back and the front were made of 1-in. boards 6 in. wide. The places for the inlay were then measured and suitable pieces of wood nailed in place. Two 1-in. boards 3 in. wide were prepared in the same manner as the 6-in. boards and clamped to the inner side of these (*Figs.* 8 and 9). Three $\frac{3}{8}$-in. rods were placed as shown in *Fig.* 9 and wired to the projecting pieces of each support. Across these irons other pieces 20 in. long were placed every 2 ft. As the under side of the seat is the part in tension the reinforcement was placed about $\frac{3}{4}$ in. over the bottom boards and not in the centre. The forms were filled with grey concrete to the level of the 3-in. boards (*Fig.* 8), which after a couple of hours were carefully extracted, after which the white concrete was poured in, making the whole one solid piece of concrete. The front and back boards were taken off after twenty-four hours and the work of rubbing with carborundum stone begun before the concrete had time to become thoroughly hard. The bottom of the moulds and the supports were left in place for a whole week. They were then used over again for the second seat.

The vases were cast in the shop. They were made altogether of white concrete and reinforced with $\frac{3}{8}$-in. rods. An idea of their size can be gathered from the fact that the upper part measured 4 ft. by 4 ft., and that it took eight men to lift that part into place. The arrangement of the tile inlays is shown in *Figs.* 6 and 9, the first not being fully completed. The finished work is shown in *Fig.* 1.

The mixtures for white and grey concrete throughout the project were as follows: For white concrete, 1 part white cement, 1 part marble dust, and $\frac{1}{6}$ part of ordinary grey cement; for grey concrete, 1 part cement, 2 parts sand, and 4 parts of $\frac{3}{4}$-in. broken stone. A little grey cement was used in the white mixture, so as to make a better bond, as the white cement and the marble dust alone have a tendency to form cracks while drying. These cracks generally do not penetrate the casting, but usually appear only on the surface. It was found that a small amount of grey cement added to the white mixture prevents cracking.

Precautions were taken in curing against rapid drying. The work was rubbed with carborundum when about forty-eight hours old.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

INDUSTRIAL "SAFETY FIRST."

By EDWARD WILLIS, F.S.I., etc.
(Member of the London "Safety First" Council).

The following is an abstract from a paper read before the Concrete Institute on February 27th, Mr. H. D. Searles-Wood, F.R.I.B.A. (President) in the Chair. In addition to the part of the paper reproduced here, there were also sections dealing with measures for the Prevention of Accidents when Industrial Buildings are in use, and measures for lessening the severity of accidents which may arise by reason of unforeseen causes.

THE subject of this paper is well worthy of the closest attention by all, and the Concrete Institute is to be congratulated upon having decided to place before its members some aspects which may appeal to them in connection with their work, as well as a wider view of the whole matter as it may affect the industrial world in this country in the future.

There are many ways in which accident or loss of life may be prevented in the industrial world, but these may be summarised for the purpose of discussion under the headings of :—

(*a*) Proper precautions during the erection of industrial buildings.

(*b*) Measures for the prevention of accidents during the period industrial buildings are in use.

(*c*) Measures for lessening the severity of accidents which may arise by reason of unforeseen causes or neglect of "Safety First" principles.

It is principally with the first of the foregoing that the constructive members of the Concrete Institute will most likely have to deal in their future professional or business capacities ; and whilst in a paper of this character it is desirable to foreshadow to some extent the whole programme of "Industrial Safety First," it may be of greater interest to those present to outline more particularly a few of the various phases of the subject as particularly applicable to them.

INCEPTION OF INDUSTRIAL BUILDINGS.

In the inception of an industrial building, preliminary surveys of the site and subsequently the preparation of plans are matters of purely professional interest, and, should the site be in the country, but few questions on this important subject are likely to arise.

The author, however, has realised in the course of more than thirty years' experience that even in this section anxieties and protective measures are met with, which may be justly entitled to come within the term "Safety First."

All industrial sites of any magnitude are now arranged for, whenever possible, alongside of a railway, a river, a canal, or an important highway, in order that the best possible facilities for the transport of goods may be immediately available.

In surveying for the preparation of plans, special caution should be given to the chain man, when taking sections of a railway for the design of sidings, as all railway companies, when issuing passes, repudiate any liability of accident and loss of life.

In the case of a river or canal, for checking soundings or levels, stable boats should always be provided, preferably of the flat-bottom type, and sufficient assistance be available with the necessary lifebelts, ropes, stretchers, and first-aid appliances in case of overturning or drowning.

Surveying on a business highway or main thoroughfare needs the greatest caution in these days of motor traffic.

In the drawing office the preparation of drawings and calculations gives only a limited scope for the consideration of our subject, but it should not be neglected even in such apparently safe places.

Assuming your industrial building plans are approved by the proprietors and by the Local Authority, the contractor then first appears on the scene, and, should he be of a practical character, this may now be considered the trend of the subject as applying to the business side of the Concrete Institute.

LAY-OUT OF BUILDINGS.

The laying out of a factory involves the erection of various temporary buildings.

Industrial " Safety First " necessitates that the position of such buildings should be most carefully determined, as in a large contract there is often a continual stream of men, women, horses, carts, vans and motors going to and from various parts of the site and the offices; and, should the latter be badly placed, accidents may probably occur.

The character of the rough roads on the site is also a matter for consideration. Careful contractors wisely provide a most carefully-constructed sleeper road, and efficiently maintain the same during the whole progress of the works, whilst others totally ignoring " Safety First " principles provide a rough hardcore, clinker, or rubbish road, often on a clay soil, with no thought of accidents to persons or strain to horses drawing heavily-loaded vehicles in the quagmires often met with in such cases during winter.

Excavations.—Industrial buildings, especially where heavy engineering foundations and tall chimney shafts are provided for in the scheme, usually involve the excavation of deep and wide trenches, and in some cases large openings. The most careful selection of properly-designed supports in the sides of the excavation, either by timber, sheet piling, proper poling and strutting, or in many contracts patent interlocking steel piling which can be used over and over again with practically complete safety and at a lower cost after the initial capital expenditure.

Too much care cannot be exercised in the design and in the application of the support to the sides of excavations.

The provision of concrete foundations is invariably a more or less simple matter, but again the elementary principles of " Safety First " are necessary to ensure freedom from accident.

Shoots for Concrete.—The provision of proper shoots for the concrete, and the elevation of the outlet of same as the concrete rises, thus giving a nearly equal distance from such outlet to the live concrete, avoid unequal splashing and consequently lead to safety by lessening the risk of accident; whereas serious alterations in the method of discharge may result in workmen hitherto prepared for existing conditions being taken unawares by the entirely different conditions of discharge, and thus liquid cement is splashed into the eyes, and claims for injury result.

Concrete Mixing.—Concrete mixing by hand when cement is used is a fairly simple matter, but if mechanical concrete mixers are used the ordinary principles of protection of moving parts should be adopted where the concrete is mixed on a more or less stationary platform. When the deposit of same is practically on the level, barrow runs become a *sine qua non*, and here again precautions against accidents on " Safety First " lines should be adopted.

Barrow runs at considerable elevations should never be by the single plank, although often adopted, when within a foot or so off the ground, with comparative safety. The best elevated run is by five running planks tightly fixed together by under-bracing, and these can be used at fair elevations with comparative safety even if not railed; but the author strongly advises that such runs, when likely to be in use for a considerable period during erection, shall be protected with a railing on either side; and again, in the erection of such railing it should not be a sham, but should consist of two bars and be sufficiently stable and strong to withstand at least the weight of two men's bodies against same.

Reinforcement.—In reinforced concrete another element of danger is at times present. Ordinary round bars so largely used in reinforced concrete construction are usually safe to handle whether clean or rusted, but certain very useful classes of metal, such as expanded metal of various kinds, split bars, and metals of a similar character, are at times extremely awkward to handle even by an expert, and too much care cannot be exercised in at once dealing with an injury such as a torn finger or palm of the hand, since if the worker is healthy and the wound at once cleaned, no serious danger may result; but if work is continued and the wound much damaged and allowed to become foul, a case of blood poisoning might arise which may not only involve a large claim, but also loss of hand, arm, or even life. Cases of overstrain through lifting heavy bars have fortunately not come within the author's past experience in this class of work, but it is not an impossible consideration, and cautions in regard to same can well be issued with a view to its avoidance, especially when such bars are to be fixed in an upright position, and insufficient help is provided. The wiring together of reinforcing rods is another section of the work which sometimes leads to what are usually classed as slight accidents to fingers and hands, but the same advice applies—viz., the immediate cleansing and protection of the wound. Of course, the avoidance of such wounds can usually be effected by heavy leather gloves and the use of proper tools, but it is a moot point if the former are always warranted when proper caution is given and care exercised.

Centreing and Shuttering.—Probably the most important section of the work by members of your Institute is in regard to the centreing and shuttering necessary for reinforced concrete structures, and no paper before your Institute on "Industrial Safety First" would be complete without some reference thereto. Unlike brick or stone structure, centreing or shuttering is required for walls as well as arches and floors in reinforced concrete, and in all vertical or steeply inclined structures double shuttering becomes a necessity.

Reinforced concrete centreing in some elaborate industrial buildings is becoming practically a specialised work, the ordinary carpenter or joiner being far less efficient in its preparation than the less skilled man at ordinary building work who has, however, been continuously engaged for some years in this particular class of construction.

Vertical centreing or shuttering requires very little external raking support as a general rule, and if carefully designed may usually be erected with none on one side, and only sufficient to keep same vertical on the other. It is, however, in the disposition of raking supports where "Safety First" principles must prevail; and again in the design of the bracing and position of the connecting bolts between the front and back shuttering, care should be exercised in order that the same are placed in such position and are of such a size as to withstand the maximum stress when the concrete is in its semi-liquid form.

Most designers construct their reinforced columns, as far as possible, by means of shuttering in certain vertical removable sections, and then the inner spaces can be filled in usually without any raking supports; in the case, however, of floors, structural supports become imperative. These may be brought up continuously from the ground or basement floor, and wherever possible, if the building is rising rapidly, struts should be in the same vertical planes as the struts below them, and where not so placed, care should be exercised that the base support is of such a size as to spread the weight of the concrete superstructure sufficiently over a suitable area.

Where heavy beams are being constructed no false economy should be exercised in making the centreing supports absolutely firm and free from movement, since a secure centreing, not touched until the concrete is thoroughly set, is a source of ultimate strength to the final structure.

It is often desirable to support the centreing of floors from above the upper surface by means of bolts through the floor, the supports being thrown on to previously constructed beams, and this method has much in its favour.

What, however, is the most important consideration in regard to the " Safety First " principle is as to the period of time when the centre should be first removed and the structure loaded. Too much caution can never be exercised in this section of the work, since in the author's opinion, and probably in the opinion of most archifects, engineers and contractors in this room, failures have resulted over and over again by reason of centreing being struck before the concrete has obtained sufficient strength. " Safety First " therefore emphasises the necessity of reasonable delay in the striking of centreing, and still more reasonable delay in the test loading of reinforced concrete structures.

FINAL TESTING OF STRUCTURE.

Assuming that the foregoing principles have been adopted, which is already done by many humane and capable contractors, the final testing of the structure, if erected to correct designs and with proper materials, may involve only a slight anxiety and but little danger ; but to err is human, and it is the human element in reinforced concrete which, in the author's opinion, is the only bar to its universal adoption.

Each floor to be tested should have been certified by the resident engineer, clerk-of-works and foreman to have received in the proper position its full quantum of reinforcement, and then the test load should be applied as directed by the specification, but the most careful consideration should be given to such loading before proceeding therewith. It is most important that no isolated portions of a structure should be unduly loaded without some consideration being given to the effect of such load on certain adjoining parts of the structure.

It might at times be reasonable that a floor, calculated for 20 tons in regular work with a test load of 40 tons specified, should not be loaded with such excess load, unless the adjoining parts of the structure were proportionately loaded, so as to counteract any buckling effect on the columns immediately below. This risk, of course, should not arise in industrial buildings, not subjected to unreasonably heavy loads ; but where the minimum reinforcement has been adopted, caution in test loading appears to be a necessary " Safety First " principle.

BUILDINGS OTHER THAN OF REINFORCED CONCRETE CONSTRUCTION.

In the foregoing the question of " Safety First " has been considered more particularly in regard to reinforced concrete structures during erection, since these buildings are erected usually with a minimum of scaffolding, but a maximum of shuttering. In actual practice, however, at present the majority of buildings are erected structurally of brick, stone, or steel, and the precautions to be taken for the safety of workers thereon are equally important.

One of the problems in the erection of an important factory or building of any kind is the provision of perfect scaffolding and appliances, and much could be written about this particular subject.

A frequent source of danger in scaffolding is the projection of scaffold boards over the ends of the putlogs or ledgers, whilst another is insufficient strength of a scaffolding to withstand safely the weight of heavy iron girders, stones, or bricks.

When a thoroughly reliable foreman with a wide experience and imbued with consideration for the care and safety of the workmen under him is employed, accidents are usually few and far between, and even those which do occur are more often caused by the carelessness of the workmen themselves than by any defect in the scaffolding provided by the contractor, or in the carrying out of the obligations thrown upon him.

There are many other causes of accidents which must occur to the minds of those present, and it is with a view of avoiding such in the future that " Industrial Safety First " principles should be instilled into the mind of every employée as well as the employer. If the London " Safety First " Council succeeds in saving the lives of only a few workmen or other members of the public its mission has not been in vain, but the author is convinced that " Safety First " and welfare measures are so allied that the movement will spread in ever-widening circles.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Lectures on Principles of Design in Reinforced Concrete. We draw the attention of students and others to a course of lectures which is being held at the Westminster Technical Institute, Vincent Square, S.W.1., by Mr. E. Sprague, A.M.Inst.C.E., on Friday evenings, 6.30 to 9.30 p.m. The lectures started on January 31st and are to run for twenty weeks. The syllabus is as follows :—

Fundamental principles of stress and strain and of the theory of bending ; bending moment and shearing force diagrams for simple and continuous girders and for ships ; use of influence lines for varying load ; properties and mixing of concrete ; calculations of the stresses in reinforced slabs and Tee beams and deductions of working formulæ and diagrams ; reinforcement in shear ; reinforced concrete columns under axial and eccentric loading ; application to retaining walls and arches, bins and silos ; L.C.C. regulations ; applications to examples. Fee for the course 5s.

A practical demonstration on cement testing, and a visit to an exhibition of reinforced concrete products may be arranged.

The Institution of Naval Architects.—The Annual Gold Medal of the Institution of Naval Architects for the past year has been awarded to Mr. A. M. Robb, B.Sc. (Associate-Member), for his paper on " The Shearing Force and Bending Moment Acting on the Structure of a Ship," and the Premium to Major M. Denny, S.B., C.B.E. (Member), for his paper on " The Possibilities of Reinforced Concrete as a Material for Ship Construction."

Planning a Works' Research Organisation.—.At a recent meeting of the Institution of Electrical Engineers Mr. A. P. M. Fleming read an interesting paper on the Planning of a Works' Research Organisation. Having dealt at length with the Research Laboratory and the Research Staff he took up the question of the Research Building. As his remarks under this heading will probably be of interest to our readers we give them below :—

In designing laboratory buildings the advice of a competent architect is necessary in all matters of a purely architectural character. These, however, should be subservient to the considerations which decide some forms of construction and some arrangements most appropriate to the laboratory as such. The research laboratories should be contained in a building separate from, but centrally situated in relation to, the works' departments. The size of the laboratory will be determined mainly by the number and character of the sections, the volume of work, size of staff, margin allowed for extension, and the amount of money available for initial outlay and maintenance.

The importance of providing a liberal amount of space initially to permit of extension without undue cost or inconvenience is emphasised. The type of building may be determined by the gross floor area needed, also possibility of extension must be borne in mind. Factors affecting the selection of a fabric are elimination of vibration, lighting, fire risk, etc. A flat roof readily lends itself to any partition of the building into sections : it offers no exposed parts to corrosion, and hence both the first cost and maintenance cost are low ; it secures the most equable temperature under external fluctuations, and it is the best form for artificial lighting. Further, a flat roof can be utilised as a proving ground, where weathering properties of materials have to be tested.

Constant use of delicate instruments demands freedom from vibration, and its reduction depends to a large extent upon the choice of fabric. A reinforced concrete skeleton and flooring for two-storey and multi-storey buildings gives the least response to disturbing forces. All buildings, however, vibrate to some extent, and precautions taken against vibration depend on internal construction.

The problem is twofold : (1) The building has to be screened from the disturbing forces set up by its own contained machinery ; (2) special apparatus may require to be screened from disturbances communicated to the building from outside. The former necessitates the isolation of unbalanced machinery in reference to the main structure. For this purpose the machinery may be housed away from the main building or situated on the ground floor or basement, preferably supported by piers built from the ground and separate from the rest of the building. In some cases it may be necessary to avoid the use of line shafting. The screening of apparatus may only require the provision of rigid tables which will not vibrate themselves, and which can be placed in positions where the vibration taken up from the building will not be serious. In this case a table top in reinforced concrete, slate, marble or like material, supported from the floor by substantial piers in brick or concrete, forms a satisfactory arrangement An example of special supports is afforded by the laboratories of Andre Citroen et Cie. Here special balances, photo-microscopic and electro-magnetic apparatus are situated on the first floor, and carried on marble tables. A typical table has four india-rubber feet which rest upon the tops of two piers rising through the basement from a common foundation of concrete and brick. Each pier consists of sections in brick, concrete and compressed cork, the latter being capped by a plate on which the india-rubber feet of the table rest. Much may be done to remove vibration troubles by providing apparatus with flexible supports loaded with a sufficient mass.

Special treatment of the problem of natural lighting is required in planning a research building, on account of the close and accurate observation which is necessary. It is important to appreciate the relative values of the intensity of illumination in the vertical and horizontal planes required for different kinds of work.

Reconstruction in Essex.—A very comprehensive scheme of reconstruction was decided upon by the Essex County Council at a recent meeting. The scheme is to include new railways, houses, roads and bridges.

Regarding the housing scheme it is proposed, in the first instance, to erect some 2,000 cottages distributed over a number of districts.

A detailed report was presented by Mr. G. Topham Forrest, the County Architect, as to the local possibilities apart from assistance promised by the Local Government Board to local authorities for the supply of transport of material. The shortage on bricks and timber was discussed. It was decided that a substitute for brick must be found for the major portion of the houses required.

As a result of inspections and inquiries, notably at Chepstow, Mr. Forrest has come to the conclusion that cottages built with concrete blocks would solve the problem. Concrete is the one material with which full advantage can be taken of local conditions, as local materials can be utilised, and on that account it is therefore an ideal material ; also from the point of view of erection it has the merit of rapidity in the rate of completion of buildings. He can only see one objection to its use, and that is the high price of Portland cement at the present time. In Essex every facility is given for concrete construction, as regards procuring the cement and the necessary aggregate, and such an opportunity should not by any chance be thrown away. The architect strongly advocates concrete block construction. The blocks are made by a machine on the site. They are specially moulded, and are more adapted for cottage building than any other form of concrete ; they are cheaper than brick or stone ; the cost of laying is less expensive than brickwork ; a considerable saving in mortar is effected ; the construction is strong and durable ; and the internal plastering is reduced to a minimum. At Chepstow the smallest house has a living-room or kitchen about 168 sq. ft. in area, three bedrooms, a scullery, with bath, fuel store, w.c., and larder. The largest cottages have a dining-room, four bedrooms, bath with hot and cold water, scullery, and offices. The main scheme was carried out during the war, and is an excellent object-lesson in concrete construction, due regard being paid to appearance. The result is eminently satisfactory, and does not by any means err on the side of extravagance. The cost of the houses varies from £450 to £550 each.

To save overlapping, efficiency, and money, Mr. Forrest divides the county for building purposes into three areas, with London, Witham, and Colchester as the respective centres. Of the 790 houses required in the outer suburban area 700 could be constructed of brick and 90 of concrete blocks ; of the 690 in Mid-Essex 25 in brick and 665 of concrete ; of the 690 in north-east Essex, 175 in brick and 515 in concrete.

With regard to cost, there is an increase of 110 per cent. on the figures of 1914, which points again to the urgent need for standardising as far as possible, and the use of substitutes for bricks. Mr. Forrest concludes : " I should like to state, in conclusion, that from practical experience I have found that it is a hindrance to the erection of cheap dwellings to educate the public to expect them to be built for figures that are impossible under altered circumstances. At this critical time I feel that talk about economy is not the first need. It is action. If action is taken, we could contrive the economy."

Reinforced Concrete Piles in the Dutch Indies.—The Dutch journal *De Ingenieur* reports that it was decided to use reinforced concrete piles on some reclaimed land to be used for building sites in the Dutch Indies. The floors of the building, designed for a load of 2 cwt. per sq. ft., were supported on girders resting on heavy concrete piles in groups of four, capable of carrying a load of 25 to 30 tons.

These piles were driven through 30 ft. of sand and 20 ft. of clay, and they were tapered from 5 in. sq. at the point to 10 in. sq. at the top. Driving operations were carried out by steam gear using a monkey of 2½ tons weight.

The reinforcement consisted of eight vertical rods, ⅝ in. diameter, reduced to four near the point, with spiral and transverse reinforcement of ¼ in. wire at 2 in. pitch.

A Concrete Freight Car.—The Illinois Central Railroad have just put into operation for their coal service a reinforced concrete freight car. The car is said to be light and the wall is 1¼ in. thick. Its tested capacity is 10,000 lb. We hope to give fuller particulars in a later issue.

Cork Harbour.—The Dredge and Works Committee of the Cork Harbour Board adopted a recommendation that reinforced concrete should be used for portion of the repair work which it is proposed to execute at two of the principal quays. This recommendation, if adopted by the Board, will mean a saving of practically £3,000 on two comparatively small but necessary jobs.

A Handsome Grand Stand.—A particularly handsome structure, in which the special advantages of reinforced concrete are shown to great advantage, is the new grand stand of the racecourse at Vienna, with a seating capacity for 50,000 persons. This structure is in three sections, one 270 ft., a second 170 ft. and the third 417 ft. in length, each section being separated from the others by lobbies 33 ft. wide. The roof of the structure slopes slightly towards the back, and projects at the front. Special consideration has been given to wind pressure in designing this roof. The various floors have been calculated to carry a load of 6¼ tons per sq. ft. in case of panic. A test load of ten tons per sq. ft. was applied to the various parts of the building with satisfactory results. Other characteristic features are the wide stairways, the large space allotted to the paying booths and the ample accommodation for refreshments. The stand was commenced in 1912, but has only just been completed. —*Beton u. Eisen*, 1918, 215-210.

The Strength of Concrete Columns.—In columns having part of the reinforcement in the form of a spiral wire, as in the Considere system, the strength of the concrete is most satisfactorily calculated by means of the expression $\frac{P}{aF_k 15F_e}$ where P is the centrally acting force, F_k the cross sectional area of the concrete, F_e the area of the vertical reinforcing bars and a is a coefficient which depends upon the shape of the column. If the height of the column divided by its diameter is x, the following values have been found by experiment :—

x	0·8	2·0	6·5
a for hexagonal columns ..	1·3	2·0	3·0
a for square columns	1·3	1·7	1·9

From this it follows that a square column is slightly smaller in area than a polygonal one. The best spiral number for F_k is 1-2 per cent. ; this number is more advantageously increased by reducing the distance between the turns of the wire than by increasing the diameter of the wire.—*Beton u. Eisen*, 1918, 216-219.

IT IS WORTH WHILE

to pay a visit to the

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Concrete Products
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This Collection includes examples of the use of Concrete in the following interests:—

RAILWAYS **ESTATE & FARM**
MUNICIPAL AUTHORITIES **ARCHITECTS & BUILDERS**
and others.

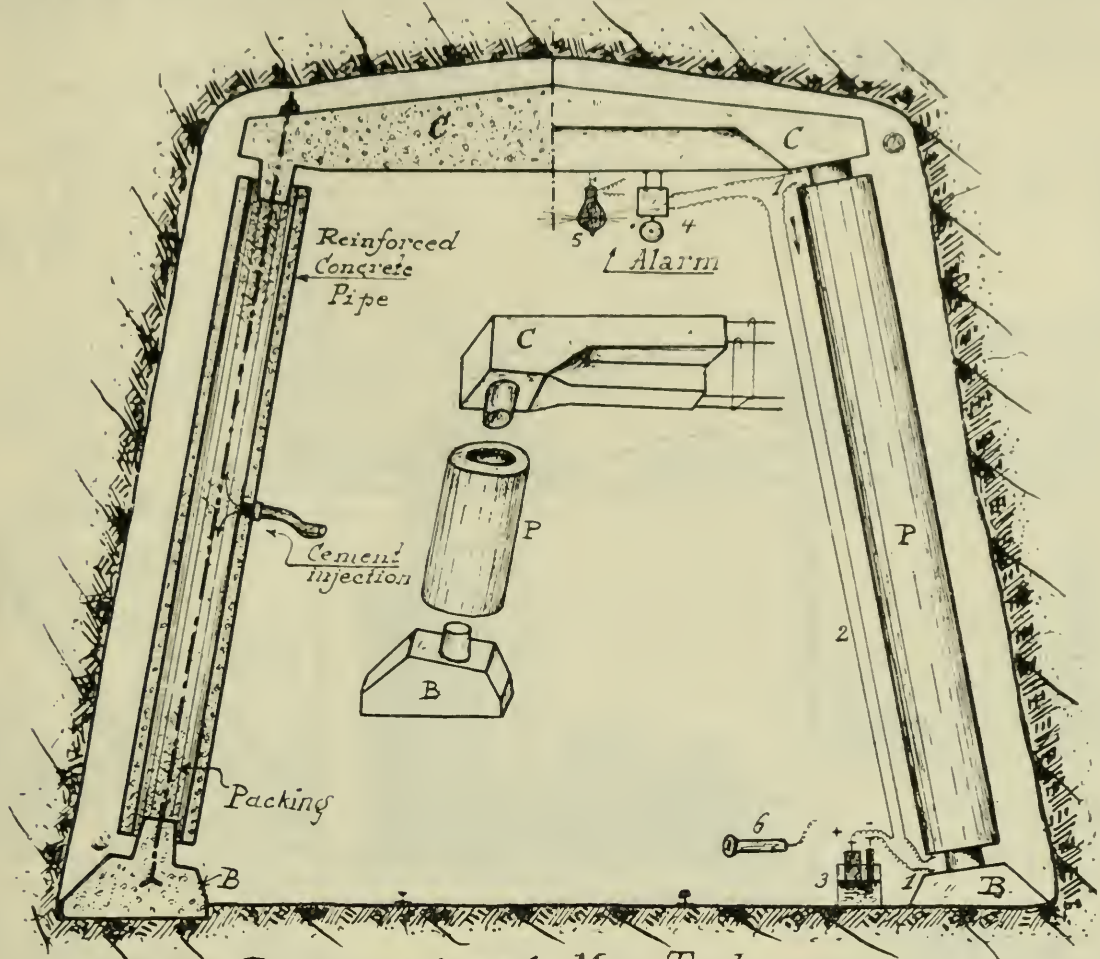
The Showroom is open daily (Sats. excepted) from 10 to 4.

ADMISSION ON PRESENTATION OF CARD.

The Exhibition has been arranged by—

THE CONCRETE UTILITIES BUREAU,
6, Lloyds Avenue, London. E.C.3.

Compressible Pit Props.—The chief objection to the use of pit props made of iron and concrete is the lack of compressibility and elasticity, but M. V. Muzak, of Brussels, claims to have overcome it. The props consist of a reinforced concrete pipe *P*, the lower end of which rests on a base *B*, whilst a crown or headpiece *C* of any desired shape fits the upper end. The pipe is filled with earth, sand or dust or a mixture of aggregate sand and cement such as are used for concrete, but without any water.



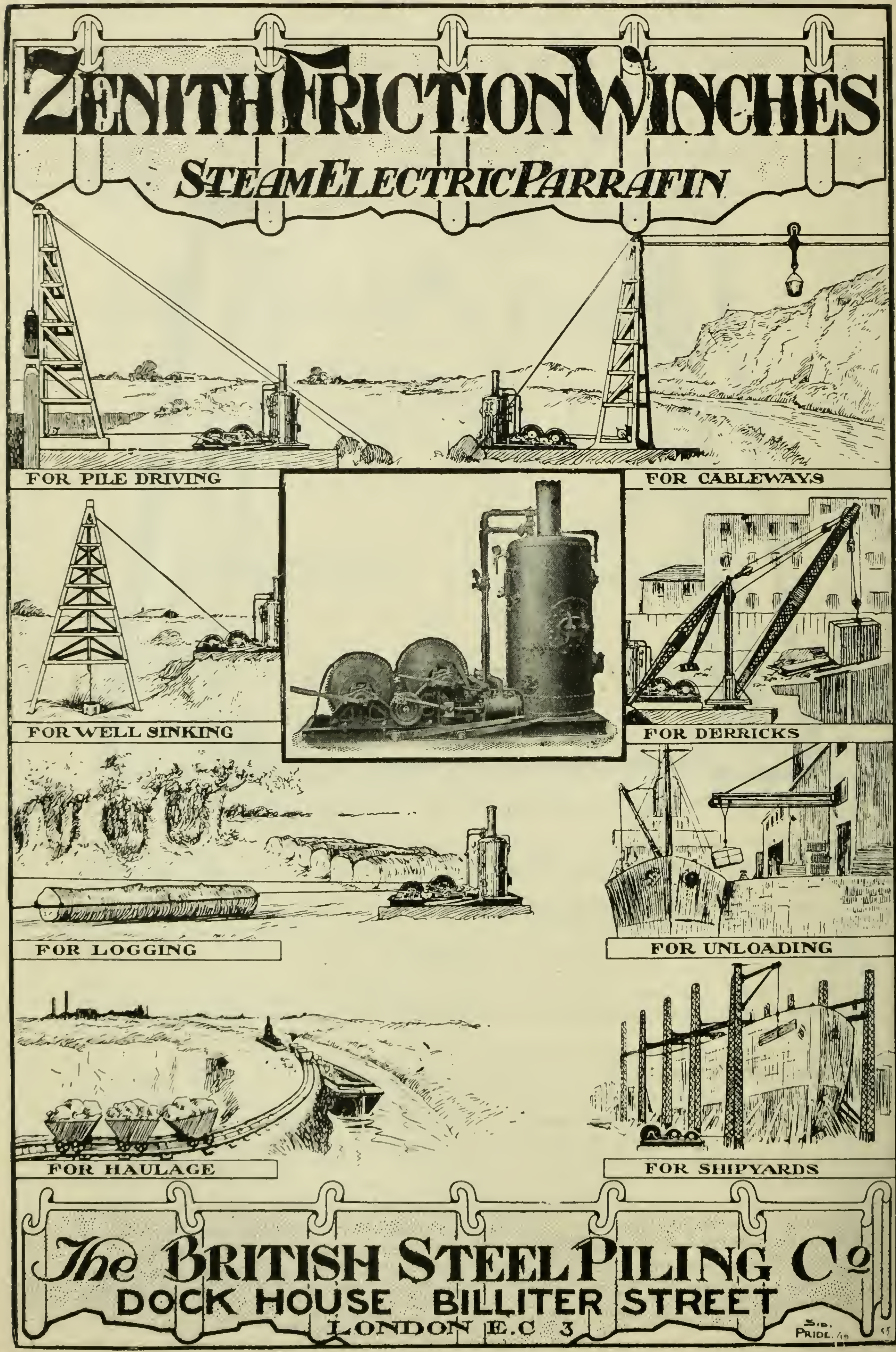
Reinforced Concrete Mine Timbering

The material in the pipe is compressed by the forces exerted during any settlement, and, if necessary, the head-piece may be raised by forcing air or water under pressure into the concrete pipe. If unexpected settlements render it necessary to make use of the maximum strength of the props the mixture previously mentioned is converted into concrete by injecting water into the pipes. Compression movements are indicated by means of the electric contacts 1, 1, bell[4], lamp[5], or telephone[6] connections shown in the illustration.

The arrangement is stated to possess a greater compressibility and elasticity than any other and to have all the advantages of wooden pit props, together with means for providing a definite degree of resistance and pressure and without any risk of fire.

Electrolysis in Reinforced Concrete.—The suggestion is made by a French scientist in *L'Année Scientifique* (Paris) that the deterioration of reinforced concrete may be caused by spontaneous electrolysis. The theory is that dampness and chemical impurities in the water employed in the manufacture of the concrete give rise to a continuous flow of local currents which slowly corrode the metal, and, little by little, cover it with a layer of oxide. The metal framework thus increases gradually in volume, so as finally to exert sufficient pressure to cause cracking and bursting.

That this pressure may be very formidable is proved by the following experiment :



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In a steel cylinder having an inside diameter of 38 mm. a steel rod 23 mm. in diameter is inserted, the free space then being filled with cement. The inside rod is then connected with an electric circuit and the apparatus placed in a tub of water. Under the influence of the current the rod will be oxidised and correspondingly increased in size. It will thus exert a pressure upon the cement surrounding it which will be transmitted to the cylinder; under the influence of this pressure the cylinder will expand, and the measurement of this expansion proves that the pressure exerted in a comparatively short time is equal to 350 kg. (770 lb.). It is obvious that even the best cement could hardly resist such a pressure.

Another experiment, even more striking, supports this view. A column of cement 30 cm. high and 150 mm. in diameter, and having an iron core running from one end to the other, was plunged into water. A 50-volt current was then passed through the iron core, which acted as the anode; in less than three hours the column of cement had entirely collapsed.

OBITUARY NOTICE.

Mr. Lucien Serraillier.—It is with great regret that we have to announce the death of Mr. Lucien Serraillier, which took place last month suddenly, after a short illness. He was a managing director of the Indented Bar and Concrete Engineering Co., with which firm he has been associated since its inception.

Mr. Serraillier was born in London and educated in this country. He commenced his career as a pupil with the civil engineering firm of Hawkshaw & Son, Westminster, and subsequently spent some years abroad in South America, the United States, and on the continent of Europe.

Soon after his return to England he became acquainted with Sir Wm. Mather, who had been much impressed with the possibilities of the use of reinforced concrete in the United States, and at his request Mr. Serraillier went to America to report on the prospects of forming a reinforced concrete company in England. On his return what was then known as the Indented Steel Bar Co. was formed, and Mr. Serraillier was appointed manager and subsequently became a director. In this connection he has done much to further the use of reinforced concrete in this country and in making its many advantages better known.

He also took a leading part in the formation of the Concrete Institute, and was a member of its Council from the commencement.

His death is not only a great loss to the firm with which he was so closely connected, but is deeply felt amongst a large circle of friends.

PERSONAL.

Mr. Ewart St. Andrews, B.Sc.Eng., M.C.I., has resigned his position in the Technical Department of the Air Ministry in order to devote his attention to consulting and patent agency work. Prior to going to the Air Ministry to take up urgent work in the design of accessories for aircraft, Mr. Andrews was for thirteen years on the examining staff of H.M. Patent Office and has entered into partnership with an old colleague, Mr. J. H. Beaumont, for the patent work. Messrs. Beaumont and Andrews, whose office address is 204-206, Bank Chambers, 29, Southampton Buildings, W.C.1., are the first members of the examining staff of the Patent Office to set up in practice as patent agents.

Messrs. Henry Faija and Co. desire to call attention to the fact that although they left Old Queen Street three years ago, clients continue to send communications there. The new address to which all letters and enquiries should go is 6, Earl Street, Westminster, S.W.1.

PUBLICATIONS.

Official Directory of the British Engineers' Association.—The British Engineers' Association have just published an official directory which should be of great value to engineers in this country and abroad. In addition to containing a list of its members, the directory contains a classified list of engineering manufactures, tables of weights and measures (metric and British) and money tables. A point which makes this directory valuable is the fact that the English text throughout is also translated into Spanish, which will prove useful in such countries as Spain and South America. We understand, however, that this directory is published in other languages as well.

The Association has at its office in London a considerable library of the catalogues of its members, and also a valuable collection of scientific and technical publications written by its members on subjects connected with the engineering industry.

Fuller particulars may be obtained on application to the Secretary, The British Engineers' Association, 32, Victoria Street, S.W.1.

The Housing of the Working Classes.—A pamphlet by T. P. Ritzema, published by *The Northern Daily Telegraph*, Blackburn. (*Price 2d., post free.*)

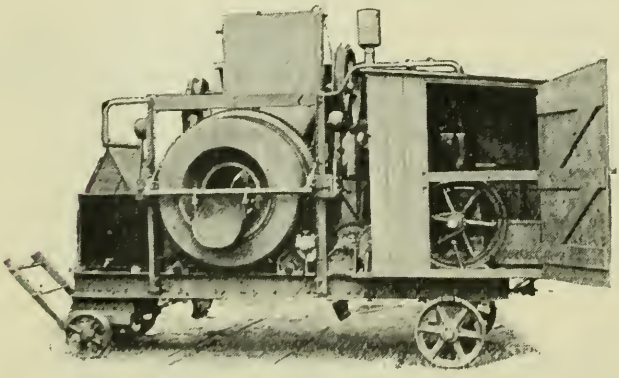
Reconstruction of Industry.—A memorandum (G. 39) by D. A. Bremner, O.B.E., published by the British Engineers' Association, dealing briefly with some factors retarding the Reconstruction and development of our peace industries and the fuller employment of the available workers of all classes.

Selwyn's Structural Library.—We are asked to call the attention of our readers to the above library which has been opened for architects, draughtsmen, structural engineers and reinforced concrete specialists. The library has been started with a view to putting books on structural engineering and allied subjects within the reach of students and others whose work compels them to keep up-to-date with current literature on engineering subjects without having to purchase these books, which are increasing in number. Some of the advantages of belonging to this library are stated to be the following :—

(1) Members of the library can at small cost read practically all the published matter. (2) Members may send up one question on the subject matter of each book, to which will be given a written reply. (3) Members may purchase soiled copies of books at reduced rates. (4) Members will be supplied with a monthly list of new publications. (5) Members requiring a book which does not appear in the list can put in an application for it, and it will be added to the Library if it appears to Messrs. Selwyn to be a useful publication.

For full particulars apply to Messrs. Selwyn, 20, Essex Street, Strand, W.C.2.

Revue du Béton Armé.—No. 1.—This is the first number of a new publication to appear monthly in Brussels dealing with reinforced concrete construction in Belgium. The first number contains, amongst other articles, one on concrete ships, and another on reinforced concrete floors.



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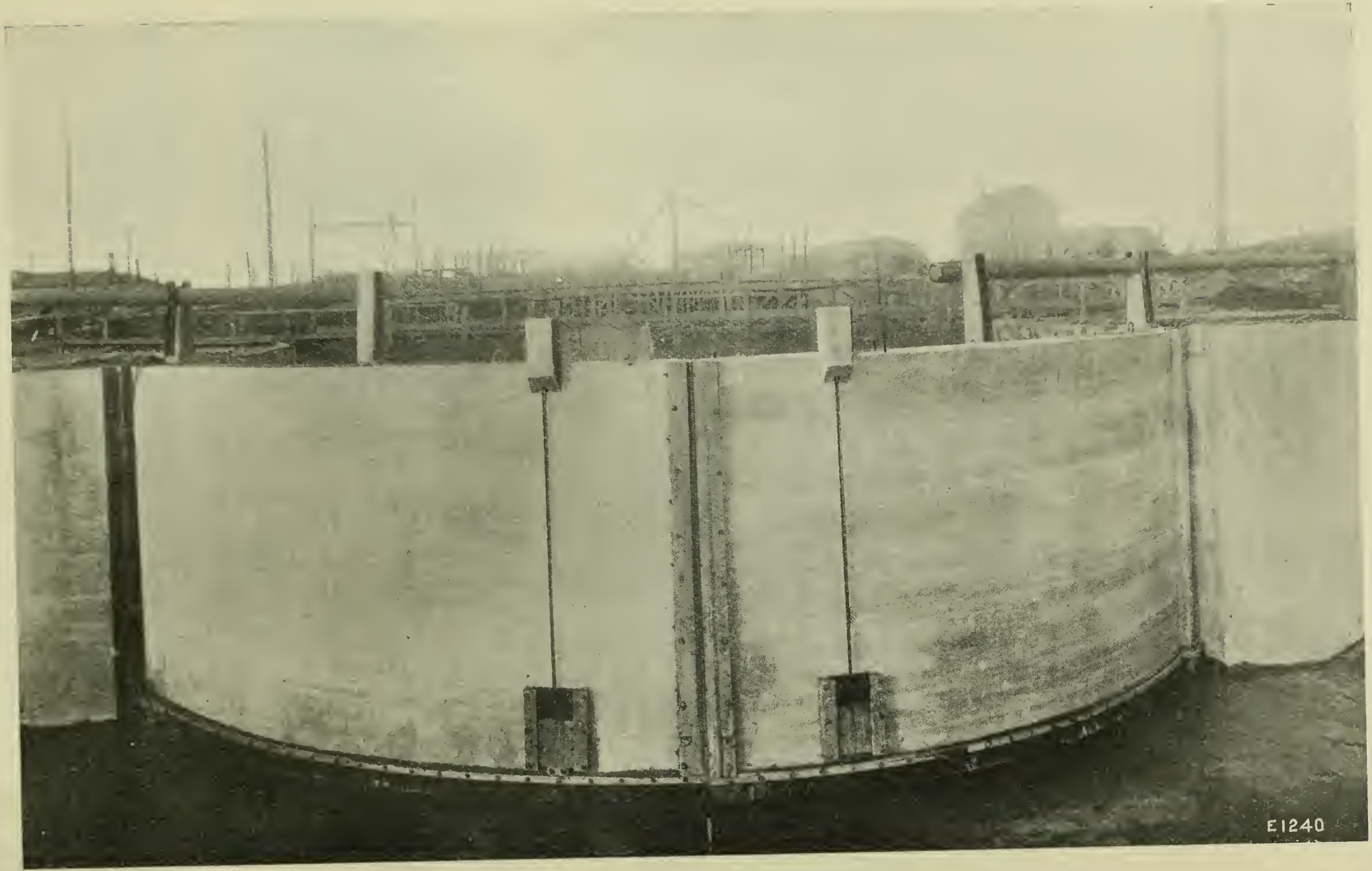

The First Concrete Dock Gate in the World.

(*For short description see page 244.*)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XIV., No. 5. LONDON, MAY, 1919.

EDITORIAL NOTES.

THE MANUAL ON THE PREPARATION OF STATE-AIDED HOUSING SCHEMES ISSUED BY THE LOCAL GOVERNMENT BOARD.

Too much attention cannot be given to this new manual * which has just been issued, because it contains a mass of information most useful to local authorities and the promoters of public utility schemes, instructing them in the methods which should be adopted in connection with the acquisition of sites, preparation of drawings and the submission of same to the Local Government Board.

It commences with a memorandum relating to the shortage and necessity of more houses, followed by particulars of the kinds of schemes for which assistance will be given, advises as to the selection and choice of sites, planning and construction of roads, number of houses to be built, together with their fencing, drainage, etc., and with regard to building in rural areas lays stress on the advantage of collecting houses in existing or new villages rather than building them in twos and threes, and points out that problems of rural education and social life would be simplified if houses are not too much scattered.

In addition to the memorandum. typical designs are included for lay-out schemes in certain eventualities, and distinguishes between what would be considered as economical and what would be uneconomical for several individual sites. Notice is also taken of the difficulties which necessarily arise in the matter of building on hilly ground where the gradients are excessive, and it is stated that as a general rule the small saving in cost which may result from placing a larger number of houses on the land is not such as to compensate for the disadvantages which follow, and that in normal circumstances the increased area of the plot obtained by adopting twelve houses to the acre is well worth the slight extra rent per plot needed to pay for the ground.

Copies of the several forms which will have to be filled in when applications are made to the Local Government Board in connection with proposals for site, for general lay-out, for approval of house plans, etc., etc., are attached as appendices, and at the end are a goodly number of illustrations of suggested house plans, making altogether a well-thought-out booklet, full of "meat," and which, if seriously considered and sensibly applied, cannot but be useful and instructive to authorities who are contemplating housing schemes.

Although the manual has been compiled especially for State-aided schemes, the information will be found equally useful for private individuals who propose to erect buildings on their own or others' land without any state or financial assistance, because it shows only too well what, at all events at the present time, is considered to be the standard for the housing of the working classes. This standard is high, and, digressing a little from the subject under review, it cannot but be a matter of the greatest concern to private owners as to how they are going to make any schemes they may propound work out on an economic basis, for what with the high prices which, for the future, must inevitably rule, both as regards labour and materials, it will be impossible to let their houses at anything like the rents accruing from the pre-war houses. State-aided schemes will be better off in this respect, as they will have the benefit of the penny rate, etc. In the end, however, be it early or later, there can be no other solution but that all rents will be economic, and such as to provide the promoters of housing schemes, private or State-aided, a reasonable return on their original outlay and the costs of repairs and re-decoration.

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* Published by H.M. Stationery Office. Price 2s. 6d.

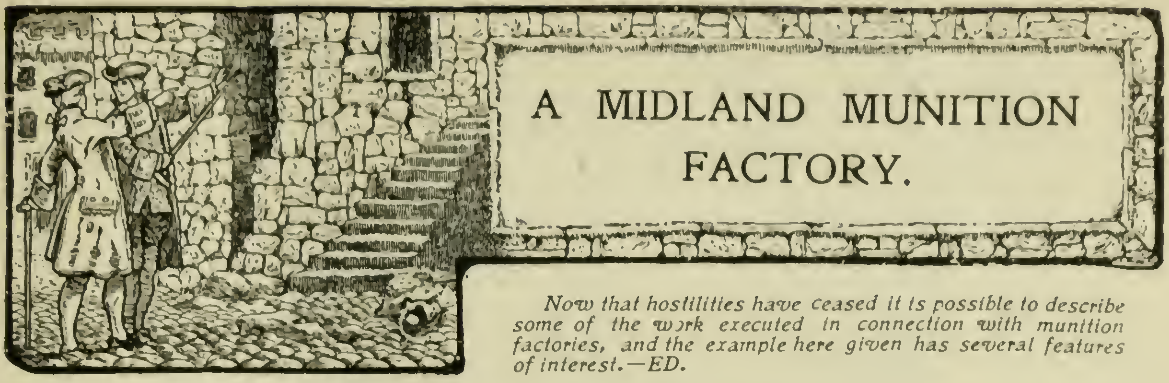
Returning to the subject in the " appended " plans, the walls are shown to be either of brick or concrete, and they are also so described in the specification ; floors are only spoken of as in wood, but doubtless there would be no objection to their being made with light concrete construction, only in this latter method there is the difficulty of the covering, which, however, can be overcome.

It is to be noted that although certain specifications and descriptions are given for almost all kinds of finishes, there is a clause which says : " Any other materials and methods of construction proposed will be considered on their merits," which is doubtless good, because it leaves the field open to any enterprising person to discover and submit new ideas, and there surely are many methods of construction which could be adopted in the erection of small houses, and which have never yet been tried.

The fact that this book is issued and so much information given to the general public is, in a way, damaging to the architectural and engineering professions, because it places in the hands of the more or less uninitiated what to some people has been a life study, and throws broadcast the finest examples, so making others as wise as themselves, and it is only to be hoped that the people who have the carrying out and management of housing schemes shall be competent and able to exercise that amount of care and control as will ensure as good a result in the actual as in the abstract.

Had the information which is contained in this manual been available earlier it would doubtless have saved a great deal of unnecessary expense, not only in the preparation of altogether unsatisfactory schemes, which have had to be " scrapped," but also in showing what was desirable and what was otherwise, and the promoters can take to themselves, in its fullest sense, the motto " Better late than never."

In any case, the manual is one to be studied and digested by everyone who has the least pretensions in connection with housing.



A MIDLAND MUNITION FACTORY.

Now that hostilities have ceased it is possible to describe some of the work executed in connection with munition factories, and the example here given has several features of interest.—ED.

By ALBERT LAKEMAN, M.S.A.

THE ingenuity and skill of architects and engineers were severely tested during the war, owing to the necessity for dealing with unique buildings for special purposes in which no previous experience had been possible, and the problems generally were handled in a manner which reflects credit on the professions. It must be remembered that the difficulties in many instances were increased by the need of speedy erection coupled with economy of materials and difficulty of quick transport; and, again, the selected sites were in many cases, and for obvious reasons, situated in a district remote from large industrial centres. The designer was compelled to adopt various types of construction to suit special requirements in different portions of the same scheme, and this fact called for expert knowledge in practically all branches of building work.

He was also required to work in sympathy with the engineers responsible for the installation of the plant, as the latter naturally governed the lines of the buildings and seriously affected the foundation work, drainage, and general level and disposition of all constructional members.

A very good example of a munition factory of unique design is that situated at Langwith, in Derbyshire, which was carried out for the Ministry of Munitions from the designs and under the supervision of Mr. E. Keynes Purchase, F.R.I.B.A., F.S.I., London. The buildings contain examples of reinforced concrete, structural steel and composite construction, and they cover an area of about ten acres. The site was selected on account of its proximity to some existing by-product works, which were capable of supplying gas for power and certain products essential to the manufacture of the particular explosive; and, in addition, railway lines, coal and water were in the immediate vicinity.

The building scheme included a large power-house with gas cleaning plant, the main factory consisting of north and south blocks, grinding house, stores, packing stores and magazine, water-softener house, pumping station, reservoir, unloading station, laundry, surgery and many other smaller buildings incidental to the main scheme. Sidings were carried to the site and the building work was commenced in November, 1915. A general lay-out of the buildings on the site

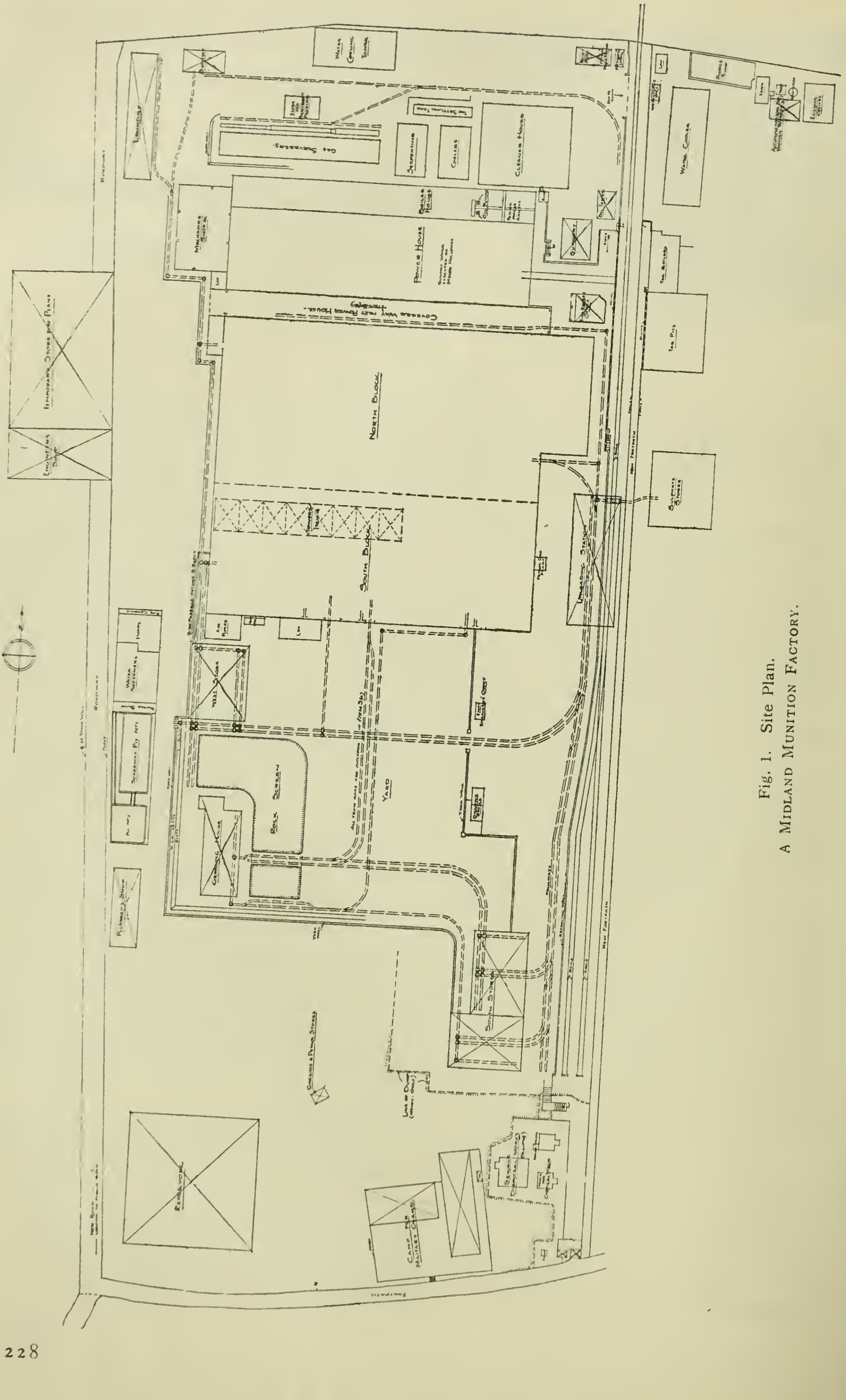


Fig. 1. Site Plan.
A Midland Munition Factory.

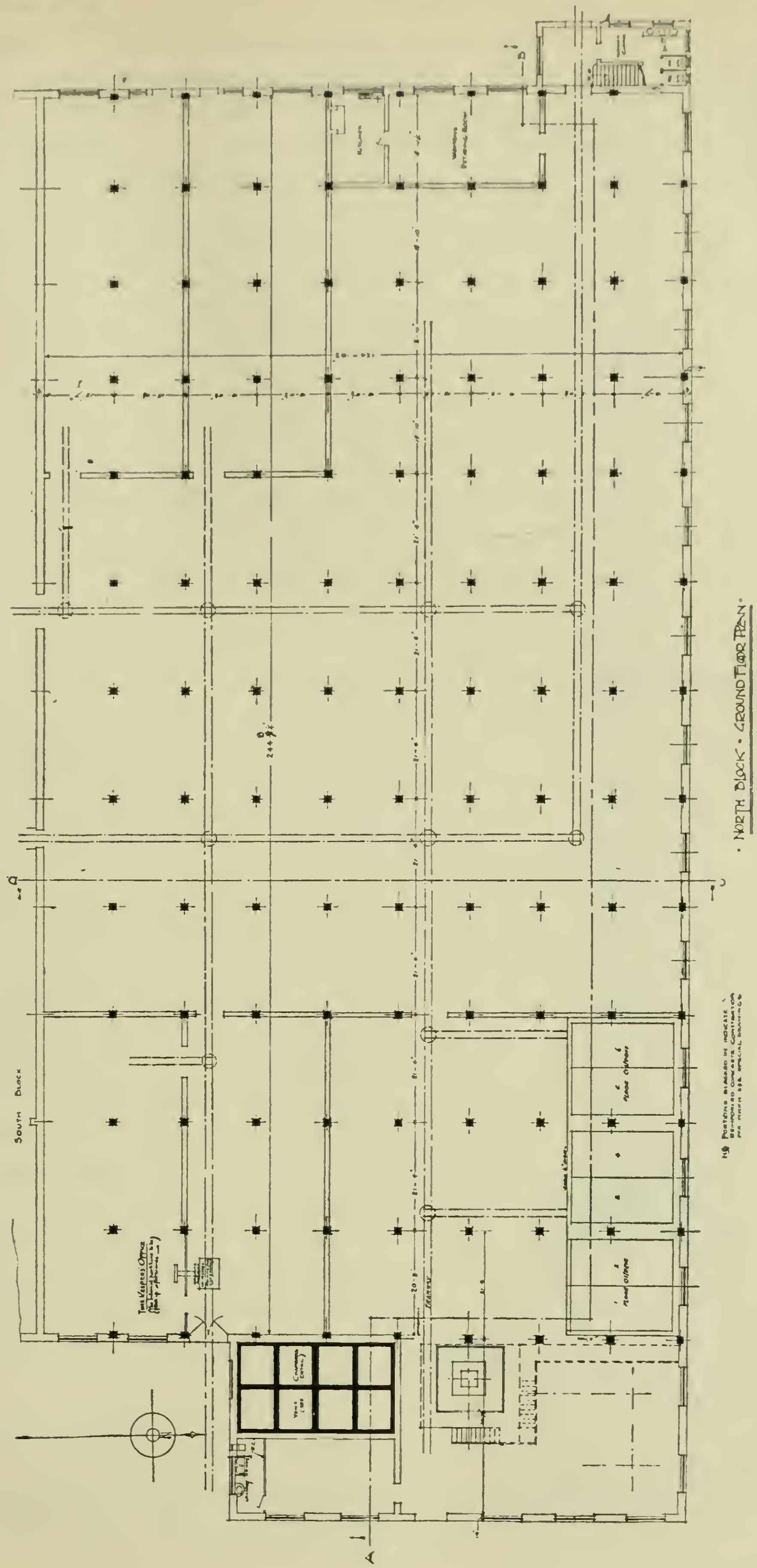

· NORTH BLOCK · GROUND FLOOR PLAN ·
SOUTH BLOCK
Time Keepers Office
Floor Over
NB Portions blacked in indicate reinforced concrete construction
A
B
C
D

Fig. 2. Lay-out of North Block.
A Midland Munition Factory.

is illustrated in *Fig.* 1, where the general arrangements can be seen. It will be noticed that the sidings are carried up on the east side of the site to serve the stores at the south end, from which the product was dispatched, and tram lines were laid to link up this siding with all the buildings and allow a complete circuit to be made. The trams also permitted a rapid transport of materials from one department of the factory to another, and thus the handling was much facilitated. Conveyors of various types were also installed inside the buildings for the movement of raw materials generally.

The power-house, which contains gas engines having a capacity of 10,000 h.p., is 225 ft. long by 60 ft. wide, exclusive of an annexe about 23 ft. wide which runs for the full length, and it has a clear height of 38 ft. from the floor level to the underside of the roof tie.

This building was constructed with brick walls, wherein steel stanchions, spaced at 37 ft. 9 in. centres, were placed for the support of the cranes and every third roof truss, the intermediate trusses being carried on brick piers, which occurred at about 12 ft. 6 in. centres. The roof trusses were constructed of steel with a large lantern running the full length of the building. There are various other buildings and features in connection with this power-house that do not contain any special constructional features.

The main factory building is divided into two portions—viz., north and south blocks—and these are quite dissimilar in design and construction.

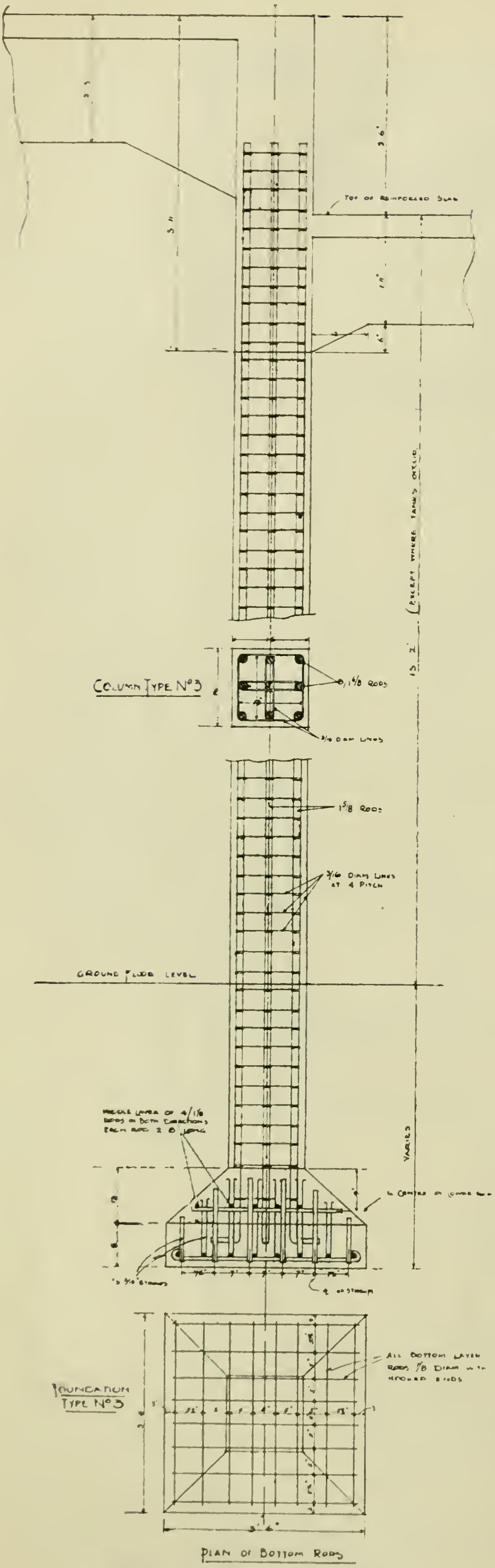


Fig. 3. Detail of R.C. Column, A Midland Munition Factory.

THE NORTH BLOCK.

The north block is two storeys high, and the building is rather unique, owing to certain requirements in the processes employed. The major portion of the ground floor is utilised as a store for raw materials, and a general plan showing the lay-out generally is illustrated in *Fig.* 2, while the first floor, which covers a similar area, is devoted entirely to manufacturing processes. The overall dimensions are about 283 ft. by 127 ft. and the outer walls are of brick. The whole of the first floor is constructed with reinforced concrete, supported by reinforced concrete columns spaced at 21 ft 4 in. centres, in one direction, and 13-ft. 11½-in. centres in the other direction. The foundation was found to be a good limestone, which requires blasting in some cases, when deep excavations were necessary ; but several fissures and pockets occurred and these were filled with a fine red sand of small carrying capacity, and in consequence, any loads from the superstructure had to be carried over these to give a bearing on the stone if the point of application of such loads coincided with a fault. Some exceptionally heavy loads occur on the first floor, and in consequence the columns had to be rather stronger than the average single-storey member. A typical detail is illustrated in *Fig.* 3, and it will be seen that the columns are 16 in. square and reinforced with eight lines of vertical reinforcement linked with binding at 4-in. pitch. Four types were employed throughout, according to the loads to be carried, but all independent columns were made of the same overall size to economise and facilitate the shuttering and the rods were varied as required, while the wall columns were 16 in. by 14 in. to suit special circumstances. The column bases are generally about 3 ft. 6 in. square, reinforced with ⅞-in. diameter rods in the lower surface in both directions and a middle layer of four rods in each direction, while the maximum thickness is 22 in., splayed down to 9 in. at the outer edges. The first floor is constructed with a raised platform 3 ft. 2 in high at one end and the remainder is partly sloping and partly horizontal, as this was essential in the process. The construction consists of reinforced concrete slabs, secondary beams and main beams, and owing to the peculiar nature of the process it was essential that nothing be allowed to penetrate through the floor, as this would have resulted in serious consequences to the process and the structure. It was therefore necessary to introduce a waterproof layer over the whole of the reinforced slabs, and this consisted of ¾ in. of asphalt laid in two thicknesses and reinforced with wire netting. This asphalt was protected from damage by overlaying it with 4 in. of plain concrete, on which was placed the surfacing material.

The slabs to the sloping and main portion of the floor have a span of 5 ft. 4 in. and the load to be carried is 450 lb. per sq. ft. The total thickness of the concrete is 4½ in., and the reinforcement consists of ½-in. diameter rods spaced at 6-in. centres with every alternate rod cranked up and carried into the adjoining bay to provide continuity. Distribution rods, ¼-in. diameter, were placed at 9-in. centres, at right angles to the main rods.

The secondary beams have a span of 13 ft. 11½ in., and they are 23 in. deep over all, and 13 in. wide. The main reinforcement consists of four ⅞-in. diameter rods with stirrups, as required, to resist shear.

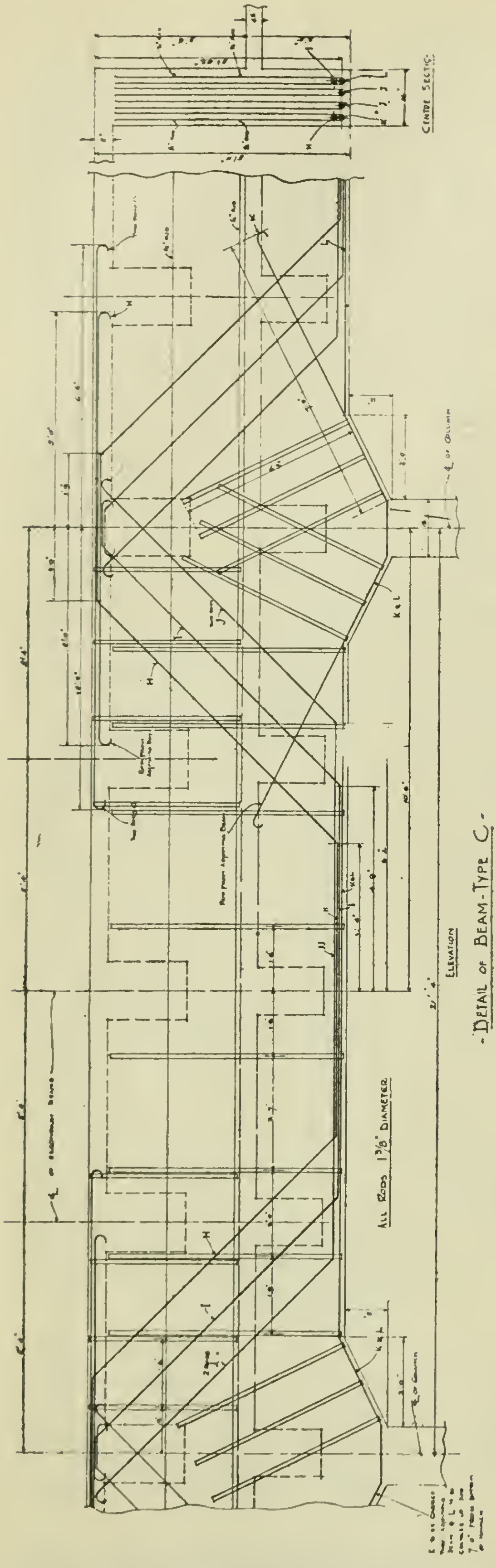


Fig. 4. Detail of Deep Beam.
A Midland Munition Factory.

The main beams, which have a span of 21 ft. 4 in., and carry the ends of six secondary beams, were limited in depth to 33 in., including the thickness of the slab, and upon calculation it was necessary to introduce compressional reinforcement.

It was found economical to neglect the value of the concrete in compression and design, the steel to take the whole of the stress thus permitting a safe stress of 16,000 lb. per sq. in. to be taken instead of fourteen times the stress in the surrounding concrete. The main reinforcement therefore consists of eight 1⅜-in. diameter rods in both upper and lower surfaces, and lateral binding was provided for the former in addition to the vertical stirrups required for shear. The slabs to the raised platform were required to carry a load of 750 lb. per sq. ft. and they are increased to 5 in. thick and reinforced with ½-in. diameter rods at 5-in. centres. The secondary beams to this portion were increased to 27 in. deep and reinforced with four 1-in. diameter rods, while the front part of the platform was designed as a beam to carry the secondary beams at the high and low levels adjoining. The total load on this beam is over 70 tons and the span is 21 ft. 4 in., but owing to the available depth being 71 in. it could be economically designed as a single reinforced beam. The main rods in the lower surface are six 1⅜-in. diameter, and to provide continuity some of them were cranked up at the ends, as indicated on the drawings. A typical detail of a portion of this beam is indicated in *Fig.* 4, and a detail of one of the main beams for the other portion of the floor and the connection between the upper and lower portions is given in *Fig.* 5. The roof trusses over the north block have a span of 42 ft. 8 in. and they are supported by 8 in. by 6 in. by 35 lb. r.s. stanchions, which are

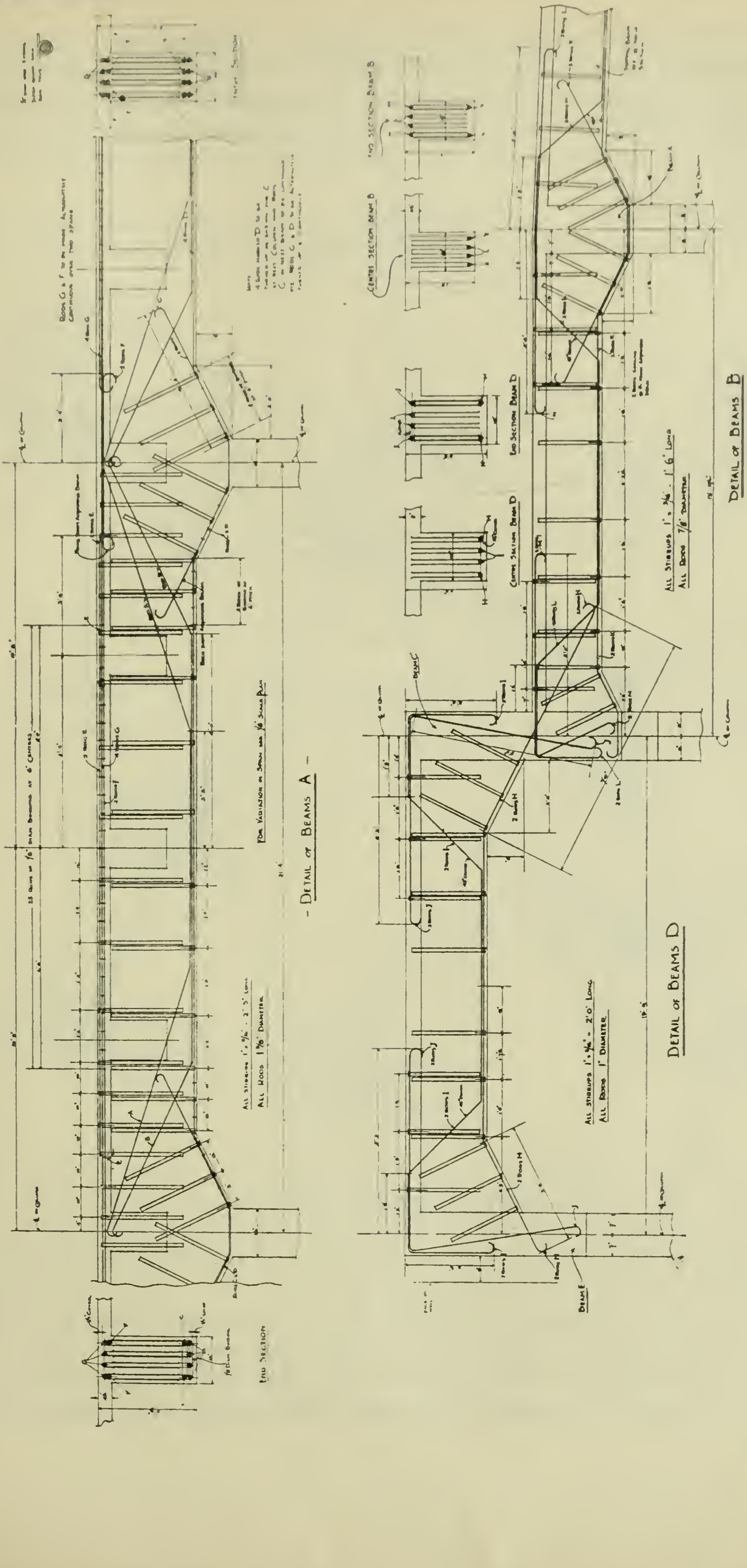


Fig. 5. Details of Beams
A Midland Munition Factory.

placed over and bolted to the reinforced concrete columns below. A detail of a typical truss is given in *Fig.* 6, and it will be seen that the main tie is formed with two 5-in. by 2½-in. channels, and these were required to take some hanging loads, which amounted to over 2 tons per truss. Opening and closing louvres were provided in the lanterns for the full length of the building and slates were used for the covering.

Reinforced concrete was employed for several underground tanks which were provided in both north and south blocks, and although these varied somewhat according to position and other circumstances a typical detail is that illustrated in *Fig.* 7, which shows the section through a pair of such tanks. The liquor to be passed through these cisterns was of a peculiar nature and it was essential that no leakage should occur, and also that no penetration to the reinforcement was possible. The internal walls had to be designed to resist the pressure caused by one tank being full while the adjacent one was empty, and they are constructed with concrete 7 in. thick, reinforced in both surfaces with ½-in. diameter rods spaced at 5-in. centres in one direction, and ¼-in. rods at 9-in. centres in the opposite direction. The floor is also reinforced in both directions

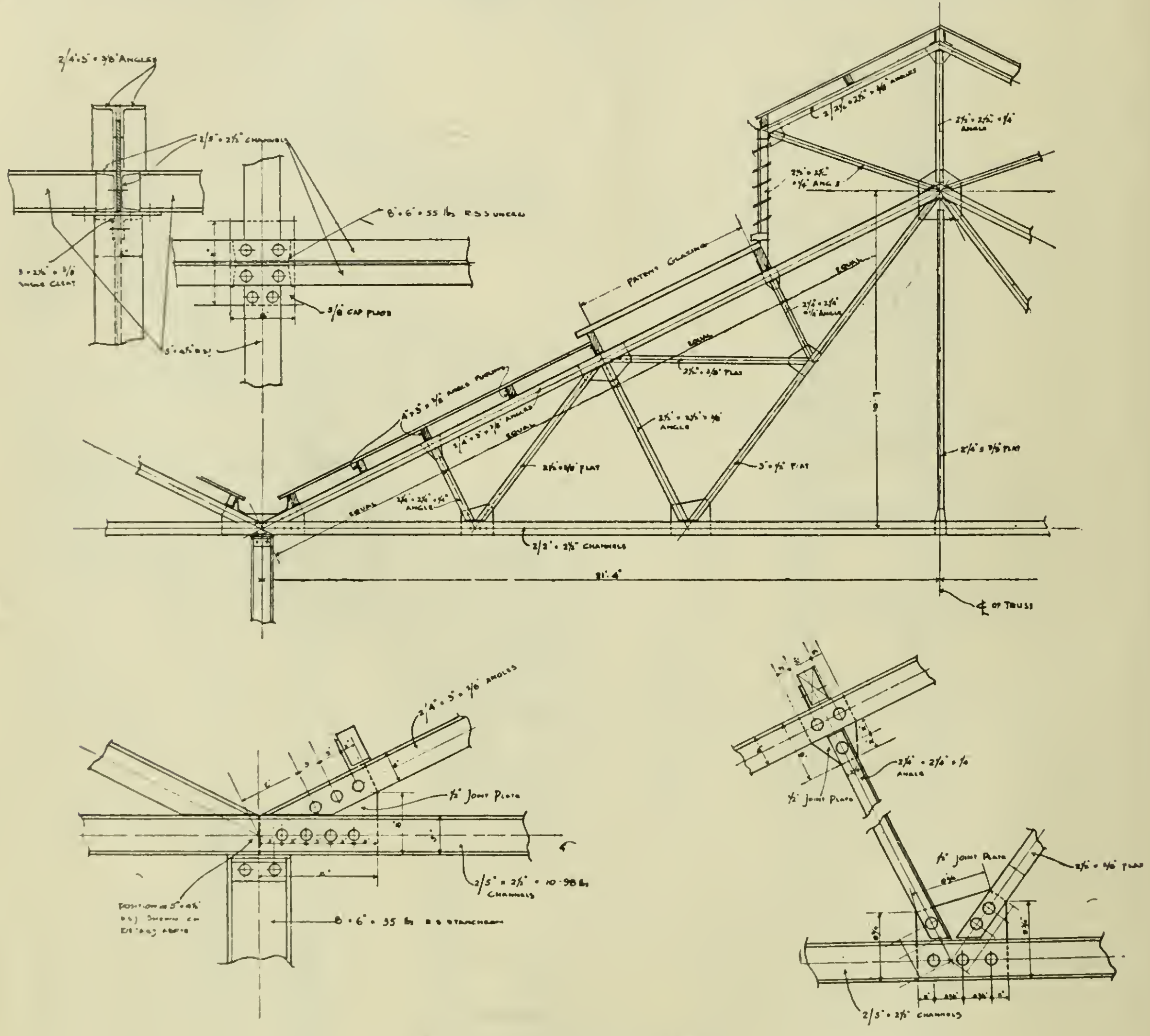


Fig. 6. Details of Roof Trusses.
A Midland Munition Factory.

and the external walls have a single lattice of rods. When the reinforced concrete was completed and sufficiently dry, the whole of the surface was covered with asphalt 1 in. thick in two layers, and this again was covered with 4 in. of plain, fine concrete formed with granite chippings, Trent sand and Portland cement.

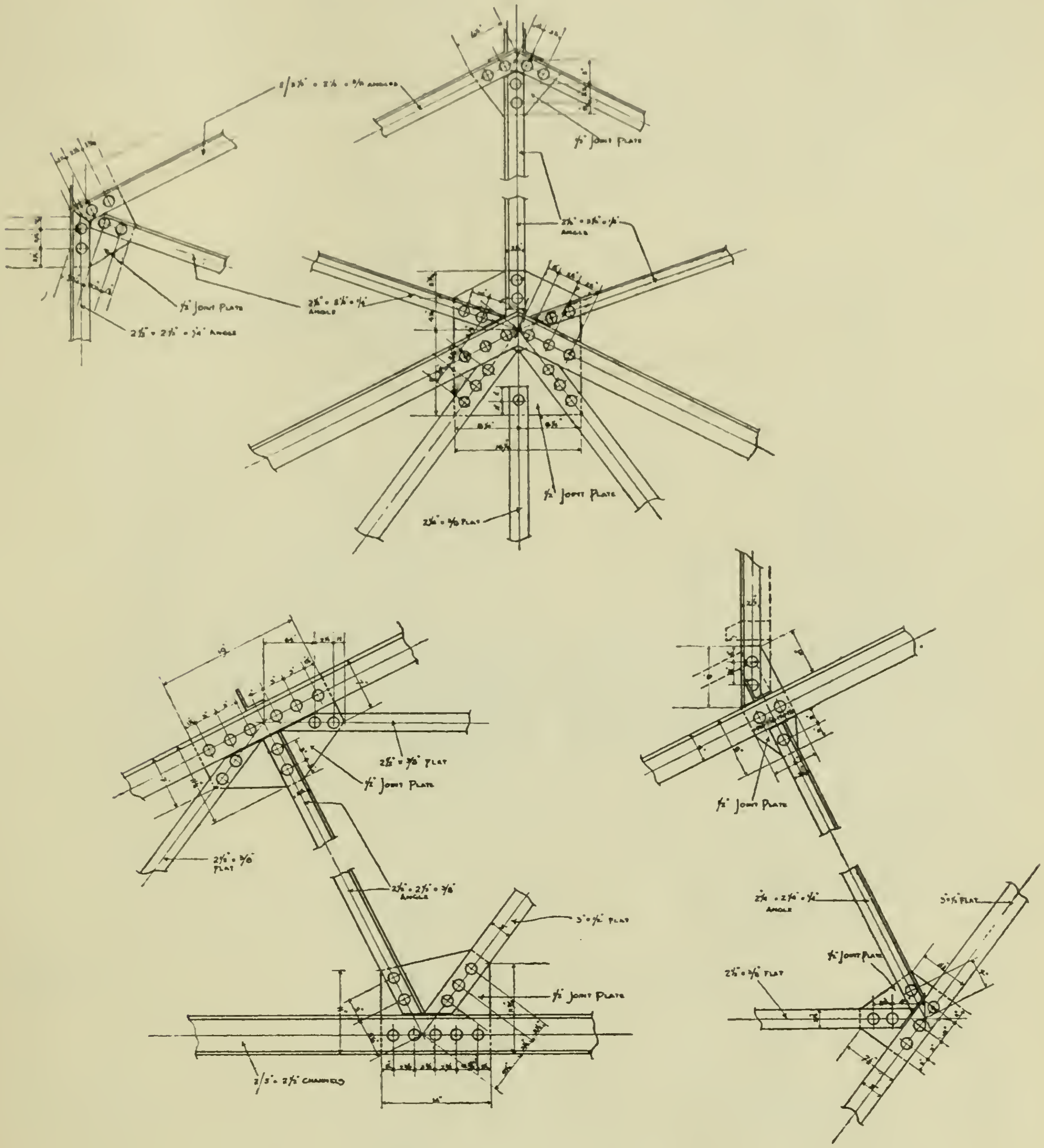
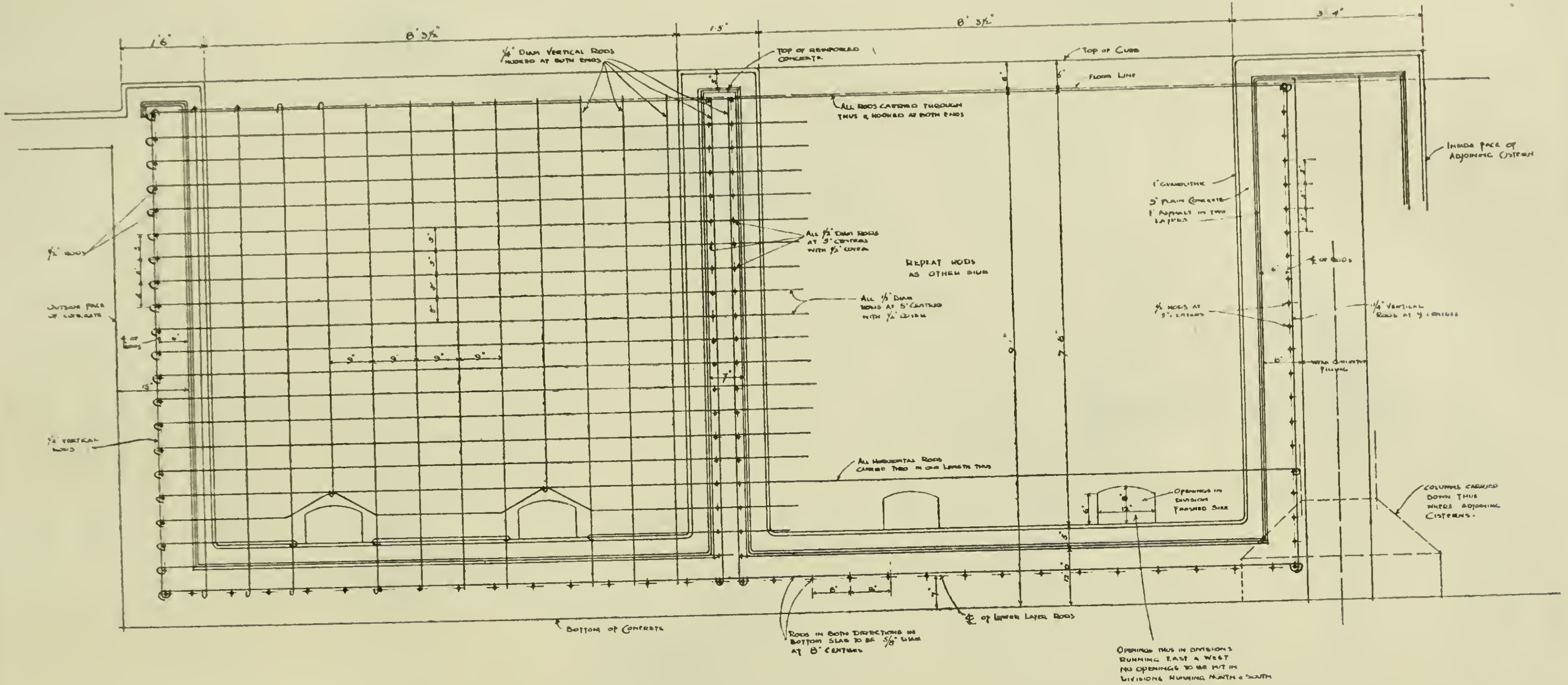


Fig. 6A. Details of Roof Trusses.
A Midland Munition Factory.

Reinforced concrete was also employed for other features in the north block, and one of these was a set of special chambers in which considerable pressure might at times be developed. These chambers are about 7 ft. 3 in. by 6 ft. 2 in. and 20 ft. high, and they are eight in number. The external and internal walls in every case are formed with concrete 12 in. thick, reinforced in both surfaces and with rods in both directions, and several openings were formed for large pipe


1'6"
8' 3½"
1.5"
8' 3½"
3' 4"
¾" Diam Vertical Rods hooked at both ends
Top of reinforced concrete
All rods carried through thus & hooked at both ends
Top of Curb
Floor Line
6"
Inside face of adjoining cistern
1" Granolithic
3" Plain Concrete
1" Asphalt in two layers
All ½" Diam rods at 9" centres with ½" cover
Repeat rods as other side
All ½" Diam rods at 5" centres with ½" cover
℄ of rods
½" rods at 9" centres
¼" Vertical rods at 9" centres
with concrete filling
½" rods
Outside face of concrete
½" vertical rods
9" 9" 9" 9"
7'6"
All horizontal rods carried thro' in one length thus
Openings in division finished size
12"
Columns carried down thus where adjoining cisterns.
Bottom of Concrete
Rods in both directions in bottom slab to be ⅝" diam at 8" centres
8" 8"
℄ of lower layer rods
Openings thus in divisions running East & West no openings to be put in divisions running North & South

— SECTION ON A.B —

Fig. 7. Details of Floor Cisterns, North Block.
A MIDLAND MUNITION FACTORY.

connections and various purposes. They are closed at the top with special large cast-iron covers, each chamber having one cover of considerable weight. A typical detail of a small reinforced concrete floor adjoining these chambers is given in *Fig.* 8, where the method employed for trimming round large pipe openings can be seen. The loads and pressures, which had to be provided for in the design of many parts of the structure and internal features, were of exceptional character and in some cases the data was of an uncertain character, owing to the fact that the processes were of a highly scientific character and quite new in this country.

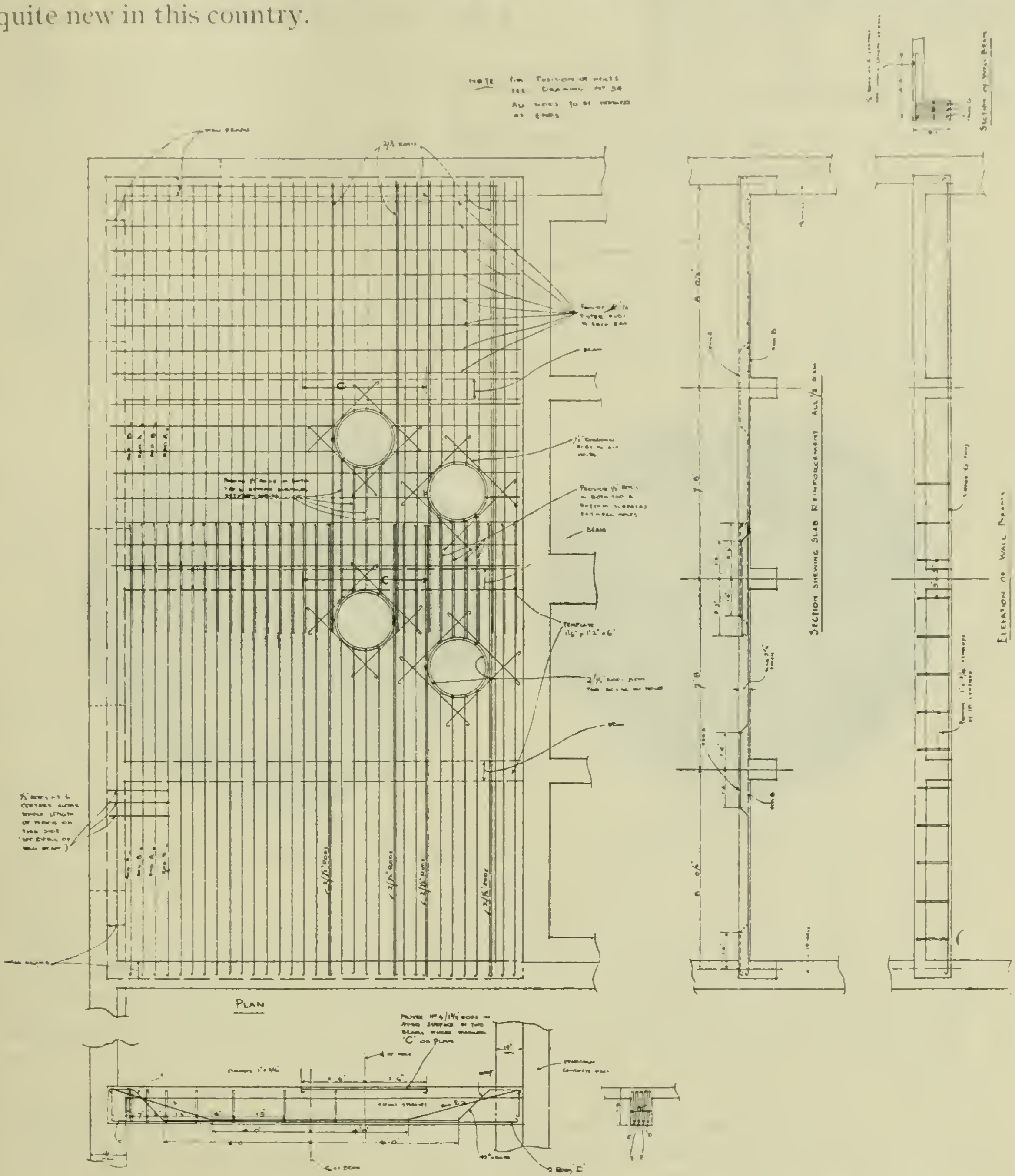
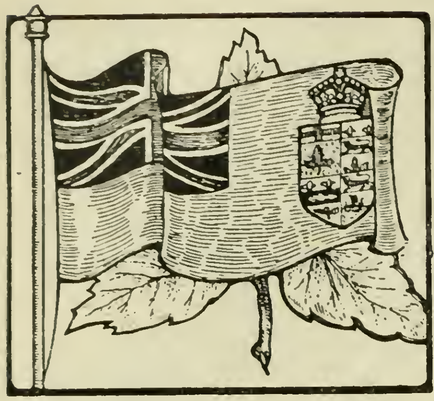


Fig. 8. Trimming Floor for Pipes.
A Midland Munition Factory.

(To be concluded.)

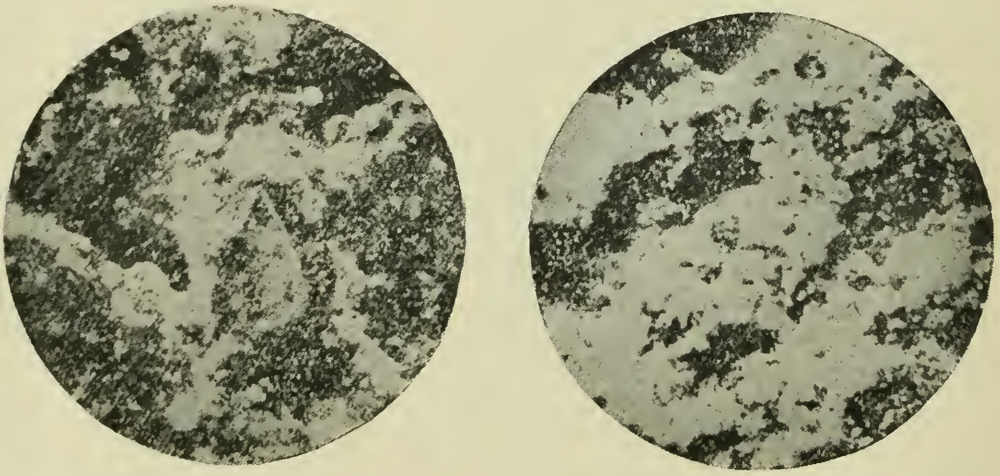


PROPORTIONING THE MATERIALS OF MORTARS AND CONCRETES BY SURFACE AREAS OF AGGREGATES.

By CAPT. LLEWELLYN N. EDWARDS,
Supervising Engineer of Bridges, City of Toronto, Ont.

Concluded from April issue, page 182.

Fig. 20 shows photomicrographs (× 75) of "normal" and of "wet" consistency mortar specimens. The latter specimen was produced from the mortar of the former by the addition of sufficient water to render it of a "mushy" rather than of a liquid consistency.



(*a*) "Normal" Consistency. (*b*) "Wet" Consistency.

Fig. 20. Texture of Cement Matrix in Mortars of different consistencies (×75).

DESIGN *v*. CONSTRUCTION.

Whether a structure be composed of mortar or of concrete, the ideal of its construction is that it shall fulfil the predetermined requirements of strength, durability, utility, etc., at the lowest cost; that is, other things being equal, economy and efficiency demand the development of the full value of the cement and of the aggregate. A large proportion of the structures now existing fall short of the ideal mainly for two reasons:—

1. Not all of the factors influencing the strength, hardness, durability and other physical properties of mortars and concretes are known and have not, therefore, been given due consideration.

2. Infallibility is not an attribute of the human mind, and, in consequence, defective structures are built, which, like chains, are no stronger than their weakest parts.

As regards strength alone, there is a most remarkable lack of "team play" between the designer on the one hand and the construction superintendent on the other. This lack of co-ordination arises most commonly from the restricted field over which each may claim, "I am monarch of all I survey." The average designer thinks in terms of pounds of compressive or of tensile stress rather than in terms of the materials to be used in the actual construction. Too frequently he clings tenaciously to the notion that a given mix will develop a given strength at an age of 28 days. For example, he assumes that a 1 : 2 : 4 mix, proportioned by the commonly used volume method, will develop a compressive strength of 2,000 lb. per sq. in., while, as a matter of fact, the 1 : 2 : 4 mix actually used in the work he designs may attain a strength of from 1,200 to 3,000 lb. per sq. in. or over. He rarely realises that in ordinary concretes of, say, 1 : 2 : 4 mix the actual cement content per cubic yard of finished concrete varies widely, due to the character and quality of the aggregates, to the consistency of the mix and to field methods and operations of mixing and placing. The average field superintendent commonly thinks in terms of bags and barrows, batches and bulks. He measures strength by the "ring" of the concrete under the blows of a hammer, which indicates that the form work can safely be removed. To him efficiency and excellence are gauged and measured not by ultimate results, but by a day-to-day standard involving an intimate combination of time, volume and pay-roll rather than by standards of strength, reliability and permanence.

The securing of greater uniformity in results approaching more closely the ideal, demands that a great amount of work be done—work not only of an educational, but also of an experimental and creative kind—involving the training of the workman and of his foreman to a different conception of their duties, that they may become more expert and efficient; the consigning to a merited oblivion of time-honoured practices and methods, unproductive of desired results; and the development and adoption of new methods and practices founded upon rational and scientific principles. This is, indeed, no menial task.

The maximum economy consistent with strength and durability will be realised when the designer can so proportion the several parts of a structure that all will theoretically be worked to equal efficiencies, and those the maximum safe ones; and the superintendent of construction can so erect the structure as to conform to the conditions assumed in the design.

There is ample evidence that in order to bring mortars and concretes to the highest standards of excellence as structural materials our efforts must be directed more specifically toward the development of a more thorough knowledge of their component materials and the improvement of field methods and practices. The suggested investigation of available aggregates with a view to determining their values as materials for the making of mortars and concretes, preliminary to the designing of a proposed structure, properly deserves further consideration.

Extended examinations cannot economically be made in connection with structures of minor importance involving comparatively small total expense. In such cases a liberal use of cement is doubtless more economical. However, there should be a certain amount of investigation. The justification of expense in connection with structures of greater magnitude, involving large quantities of mortar or of concrete materials, is a quite different proposition when considered from an economic viewpoint. The results of the tests herein described give ample evidence of the economy of well-graded sands when used as aggregate for mortars and concretes proportioned in accordance with the surface-area method. It will frequently happen that such an investigation will involve only the collecting and testing of sample aggregates secured from commercial companies dealing in these materials. In other cases an investigation might involve a search for satisfactory sand and gravel deposits or for quarry sites.

It is an encouraging fact, and worthy of note in passing, that tests of aggregates are being regarded as of much greater importance and are receiving correspondingly greater attention than formerly.

PRACTICAL APPLICATION OF THE METHOD.

The adaptation of the surface-area method of proportioning mortars and concretes to both laboratory investigations and to field construction operations presents no serious difficulties. The outstanding feature of this method, in so far as its practical application is concerned, is the importance of knowing the granulometric composition of the aggregates. It must be admitted that the securing of this all-important information involves a comparatively small amount of labour, and by way of equipment the use of only the necessary scales, standard sieves and screens. The time element involved is comparatively negligible, since, as described more fully herein, the computation work of determining areas and quantities of cement can be largely reduced to the most simple mathematical operations by the use of tables and diagrams. For use in the laboratory and in the field, diagrams drawn to a large scale increase accuracy and reduce labour.

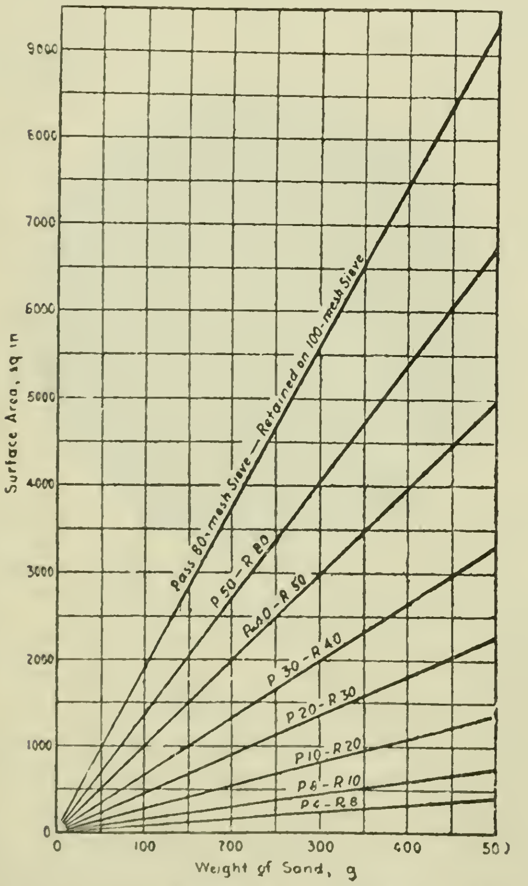


Fig. 21. Surface Areas (sq. in.) corresponding to various weights of Sand Aggregate (g).

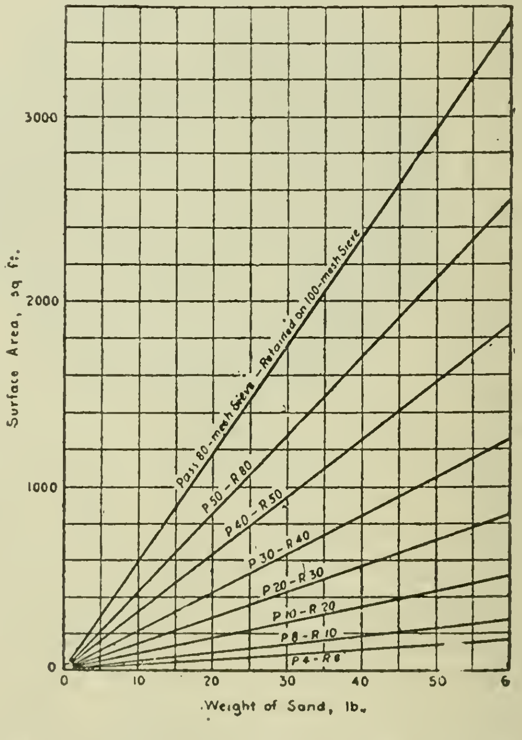


Fig. 22. Surface Area (sq. ft.) corresponding to various weights of Sand Aggregate (lb.).

*Figs.*21 & 22 are designed for use in determining the surface areas of sand aggregate. The former is intended for laboratory use and the latter for both laboratory and field use. These diagrams are derived from information contained in Table III.

Fig. 23 is designed for use in determining the surface area of stone aggregate and is intended for both field and laboratory use.

Fig. 24 shows a conversion diagram for determining the relative quantity of cement in pounds per 100 lb. of sand from the corresponding relation of cement in grams to the surface area of 1,000 g. of sand and vice versa.

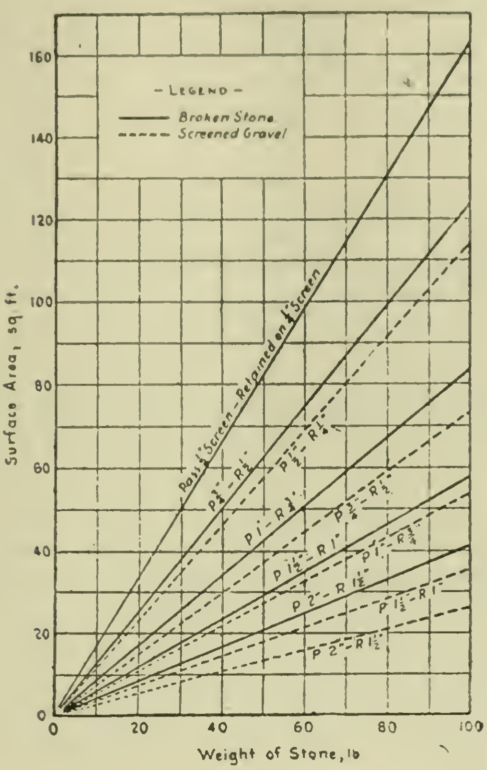


Fig. 23. Surface Area (sq. ft.) corresponding to various weights of Stone Aggregate (lb.).

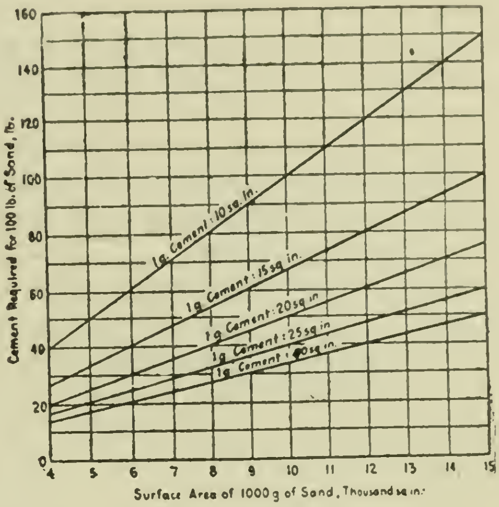


Fig. 24. Weights of Cement (lb.) per 100 lb. of Sand Aggregate corresponding to various surface areas per 1,000 g. of Sand Aggregate and various proportions of Cement to Surface Area.

Use of Diagrams.—The following examples explain the method of using the diagrams shown in *Figs.* 21 to 24 inclusive :—

Example No. 1.—Required to find the composition of a batch of mortar using 1,000 g. of sand *A* and a cement content proportioned : 1 g. cement to 15 sq. in. sand area.

SAND AREA.

Sieve.	Grading, per cent.	Weight, g.	Area (*Fig.* 21) sq. in.
P 4–R 8	15·0	150	142
P 8–R 10	5·0	50	75
P 10–R 20	25·0	250	694
P 20–R 30	15·0	150	676
P 30–R 40	15·0	150	997
P 40–R 50	10·0	100	992
P 50–R 80	10·0	100	1,348
P 80–R 100	5·0	50	932
Totals	100·0	1,000	5,856

$$\text{Cement (g.)} = \frac{5856}{15} = 390{\cdot}5$$

$$\text{Water (c.c.)} = 390{\cdot}5 \times 22{\cdot}25 \text{ per cent. (normal consistency)} + \frac{5856}{210} = 115.$$

Example No. 2.—Required to find the composition of a batch of concrete using 100 lb. of sand *A*, 200 lb. of broken stone graded as shown below, and a cement content proportioned : 1 g. cement to 15 sq. in. aggregate area.

The area of the sand aggregate is determined as shown in Example No. 1 except that *Fig.* 22 is used, therefore : Sand area (sq. ft.) = 1,845 sq. ft. per 100 lb.

STONE AREA.

Screen.	Grading, per cent.	Weight, lbs.	Area (*Fig.* 23). sq. ft.
P $1\frac{1}{2}$ in.–R 1 in.	60·0	120	6·90
P 1 in.–R $\frac{3}{4}$ in.	25·0	50	41·5
P $\frac{3}{4}$ in.–R $\frac{1}{2}$ in.	10·0	20	24·5
P $\frac{1}{2}$ in.–R $\frac{1}{4}$ in.	5·0	10	16·0
Totals	100·0	200	151·0

Total area of aggregates = 1,996 sq. ft.

Cement (lb.) = 19·96 × 2·11 (*Fig.* 24) = 42·12 lb.

PRACTICAL LIMITATIONS.

It is especially important to note that in its application the surface-area method of proportioning admits of certain physical limitations. The more important of these are here discussed briefly.

Effect of Dust.—The effect upon the physical properties of mortars and concretes of a sandy " dust " passing a No. 100 sieve is not definitely known. The main feature to be considered in this connection is the relation of the sizes of the " dust " particles to the sizes of the cement particles. A microscopic examination of the cement used in the tests described in this paper showed the sizes of the greater portion of the cement particles to range from 1·5 to 3·3 μ[1] in their largest dimensions with an average dimension of approximately 2·2 μ, that is $\frac{1}{11,540}$ in. Some of the larger particles measured ranged in size up to 6·7 μ.

Disregarding entirely the effect of the surface tension of the water used in the mix, it is reasonable to assume that the particles of dust do not become " coated " with cement paste, but that instead they become linked to adjoining particles of aggregate by one or more separate cement bonds. Doubtless the cohesion existing between particles of cement is greater than the adhesion existing between these particles and the particles of dust or other aggregate. It follows, therefore, that the strength of the mass must be somewhat weakened by the inclusion of dust in the aggregate.

Laboratory v. *Field.*—The most important difference between the preparation of mortars in the laboratory and the field is found in the methods of mixing. In the laboratory the operator submits the mix to a thorough kneading and squeezing which forces the component materials into the closest possible contact with each other. In the field the mixing and frequently much of the work of transporting and placing tends to separate and break up rather than to knead and compact the mortar mass.

Field construction conditions are never ideal, even when carried on under the most careful supervision. In consequence, the strengths and other physical properties of field-made mortars and concretes frequently differ widely from the results obtained by tests made in the laboratory, in accordance with standard laboratory practice, with the object of obtaining a measure of the constructive value of the materials.

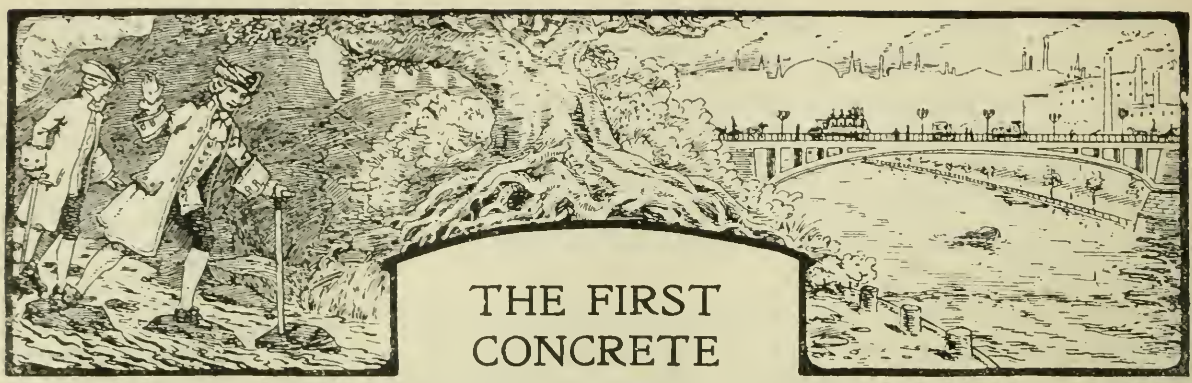
Coarse v. *Fine Sands.*—Mortars in which the sand aggregate contains a comparatively large proportion of coarse particles are subject, during mixing and placing operations in the field, to an intensified movement of the water content which tends to produce an improper distribution of the cement. This condition is most noticeable in concreting operations.

When mixed to "normal" consistency, so-called well-graded sands do not produce mortars which are as "workable" as those in which the sand aggregate contains larger percentages of smaller sized particles.

As compared with mortars containing well-graded sand aggregate, mortars containing aggregates composed entirely of fine particles must be subjected to a greater amount of mixing in order to secure a uniform distribution of the cement by a thorough abrasion which will separate the fine particles of aggregate tending to cling together.

Wet v. *Dry Sand.*—The amount of moisture existing in the sand aggregate constitutes one of the most commonly disregarded sources of variation in the strength of field-made mortars and concretes. Various tests have shown that the surface tension of the water film enveloping the sand particles holds the particles apart, thus producing a decided increase in the gross volume. Sands made up of fine particles, and in consequence having greater surface area, increase more in volume than coarse sands. It is evident that a disregard for this important factor may produce materials the ultimate strengths of which are quite different from those contemplated in the design.

Acknowledgments.—The writer takes sincere pleasure in here giving due credit to J. S. Burgoyne, A. S. Goss, R. G. Goss, W. G. Howse, H. W. McAll, F. G. Marriott, and C. E. Stilson, who have rendered worthy assistance in the making of test specimens, chemical and physical tests and photographs, and in the tabulation of data.



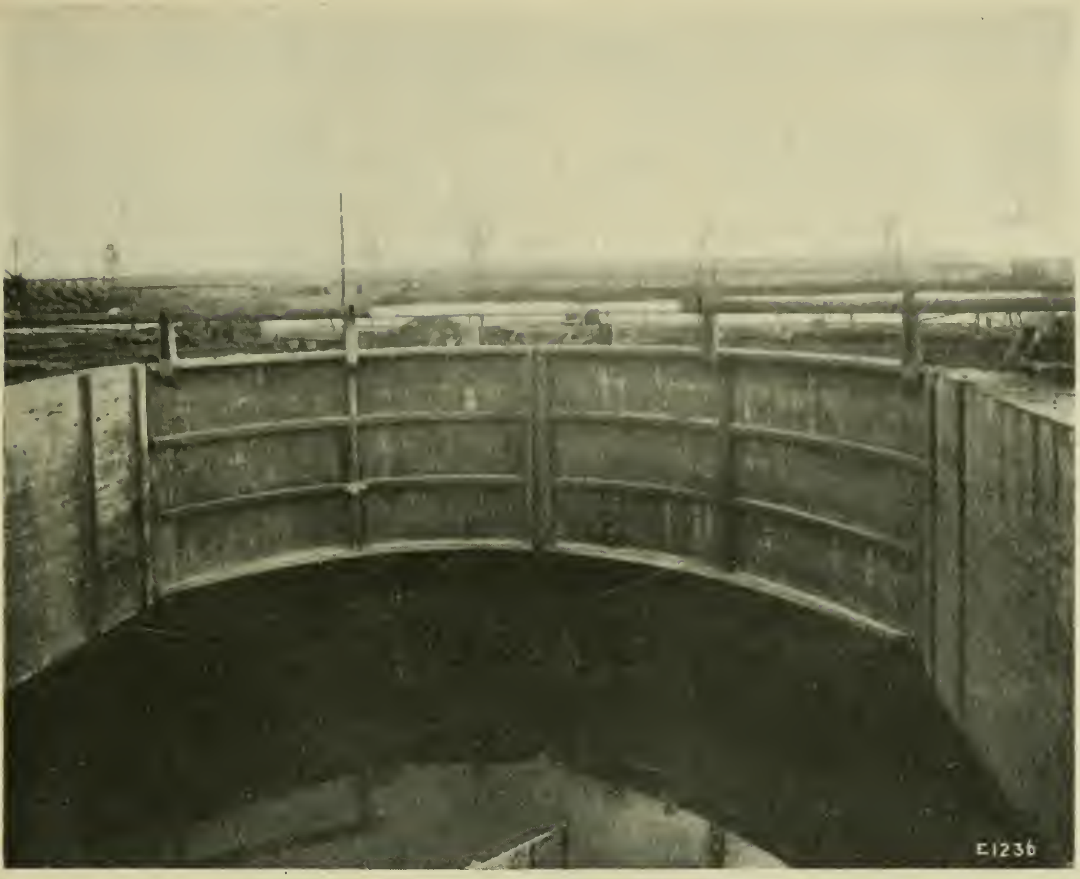
THE FIRST CONCRETE DOCK GATE IN THE WORLD.

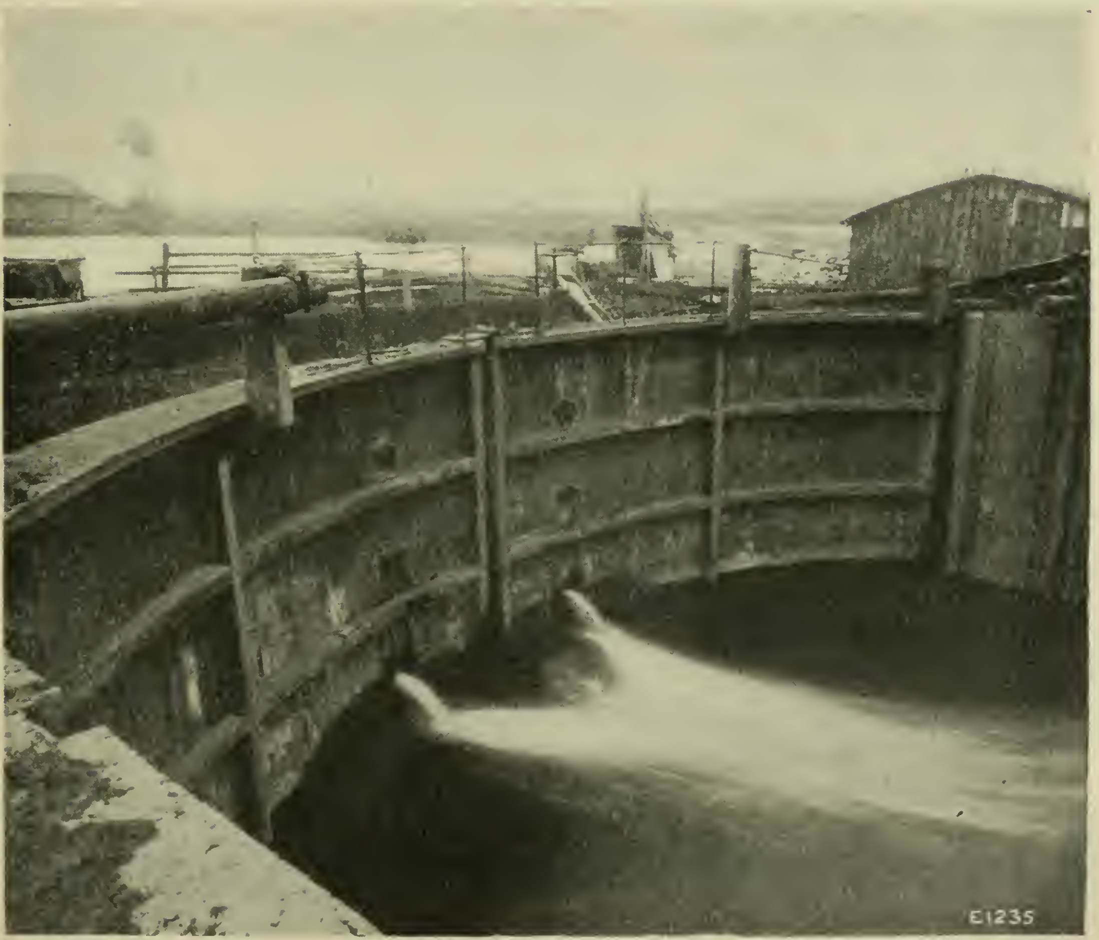
An interesting and entirely novel application of reinforced concrete is its use for dock gates, and we are enabled, by the courtesy of Messrs. Christiani & Nielsen, to publish the following particulars and illustrations of the first dock gates constructed in this material at Tilbury.—ED.

During the autumn of last year, when timber and steel were difficult to obtain, it was decided to introduce reinforced concrete for the purpose of constructing a system of dock gates connecting the private dockyard of Messrs. Christiani & Nielsen at Tilbury Dock with the Port of London Authority's main dock at this place.

The former dry dock was built for the purpose of constructing five reinforced concrete colliers for the Admiralty, and was completed, together with the five vessels, within a year. The vessels having a beam of 35 ft., the canal connecting the dry dock with the Tilbury main dock was constructed with a minimum width of 40 ft. to afford sufficient clearance for vessels when passing through the canal into the main dock, and the free span of the dock gate in question is therefore 40 ft., the depth of the gates being 14 ft. The gates are constructed as stress line for uniform water pressure, and are therefore circular in shape, as will be seen from the photographs, and although they have to stand a water pressure of 14 ft., the thickness of the circular slab forming the gates is only 3½ in., which, however, has proved quite sufficient in actual practice. No waterproofing compound of any description has been used for the concrete forming the gates, nor any surface treatment of any kind. The gates, however, are perfectly watertight.

As will be seen from the photographs, they are formed as ordinary doors on top and bottom hinges, and the ease with which they are moved is illustrated by the fact that two men can easily open and close the gates. Special precautions had to be taken in the construction of the hinges, so as to allow the gates to take up their proper stress line position, and it was found that floating hinges at the top and at the bottom, combined with an elastic medium for closing up against the bottom sill, proved an efficient and successful way out of the difficulty.





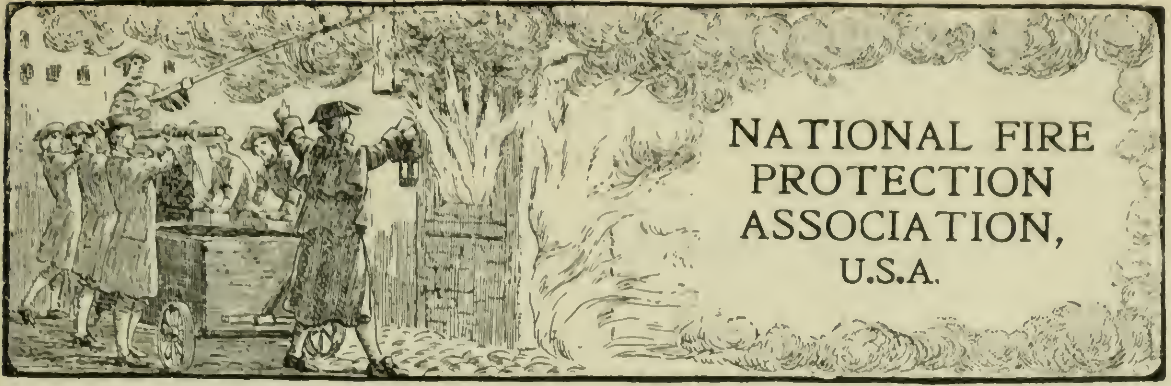
A CONCRETE DOCK GATE AT TILBURY.

The water is let into the dry dock by means of two sluices operated in the usual way.

The abutments which have to take the total thrust from the arch action of the circular gates had to be founded on 50 ft. long reinforced concrete piles, in order to provide a sufficiently rigid and immovable support, as the soil in question was totally unsuitable for taking the pressure met with in this case.

These dock gates were designed and constructed under the supervision of Mr. R. N. Stroyer, of Messrs. Christiani & Nielsen, 25 Victoria Street.

In conclusion, we would add that the Port of London Authority gave every facility and assistance in the carrying out of this work.



Committee on Inflammable Liquids: Edward A.
Barrier, Chairman, 31 Milk Street, Boston, Mass.

TENTATIVE REGULATIONS FOR CONCRETE TANKS FOR THE STORAGE OF FUEL OIL.

The following regulations were submitted for consideration at the Convention of the National Fire Protection Association held on May 6th, by the Committee on Inflammable Liquids, of which Mr. Edward A. Barrier, is the Chairman.—ED.

1. CAPACITY AND LOCATION OF TANKS.

See Sections 1 and 29 (*b*), (*c*), (*d*) and (*e*) of "Regulations for the Installation of Containers for Hazardous Liquids."

2. SETTING OF TANKS.

(*a*) Tanks, if underground, shall be buried so that the top of the tank will be not less than 3 ft. below the surface of the ground and below the level of any piping to which the tanks may be connected.

(*b*) Tanks shall be set on a firm foundation.

(*c*) All tanks shall be provided with a concrete or other non-combustible roof.

3. MATERIAL AND CONSTRUCTION OF TANKS.

(*a*) *Reinforcement.*—Sufficient steel reinforcement shall be used to resist the oil pressure, and the horizontal and vertical reinforcement shall be proportioned properly and located to reduce the shrinkage cracks, so that they will be too minute to permit leakage. The fibre stress in the steel shall not exceed 10,000 lb. per sq. in.

NOTE.—A fibre stress of 10,000 lb. per sq. in. should prevent shrinkage cracks, although a number of tanks have been designed with a fibre stress of 6,000-8,000 lb.

(*b*) *Concrete.*—The concrete for floor and walls shall be at least 8 in. thick, mixed in the proportion of 1 : 2 : 3 ; or, better, 1 : 1½ : 3, and having the coarse aggregate of clean, dense, crushed rock or gravel, ranging in size from 1 in. down. The concrete shall be thoroughly mixed, carefully placed and worked around the reinforcement. The forms should not be held together by wire, as is frequently done in building construction, because leakage is likely to take place along the wire.

The concrete shall preferably be poured in a continuous operation so as to form a monolithic construction.

NOTE.—Where this cannot be done, the bottom shall be poured without joints and the walls as a second continuous operation. One method of making a tight joint between the bottom of the tank and the walls is by means of a strip of galvanized iron, 6 in. wide, with joints riveted and soldered, so as to form a continuous band. This strip should be vertically embedded 3 in. in the floor slab and on the centre line of the wall. The floor slab under the walls should be thoroughly cleaned, and, before pouring the walls, a mixture of 1 : 1 mortar should be placed in the bottom of the forms and around the galvanized strip to make a tight joint.

(*c*) *Finish.*—As soon as the wall and sides have been poured, the floor shall be floated and trowelled smooth. The wall forms shall be removed as soon as the concrete has hardened sufficiently to be self-sustaining, and all projections and irregularities shall be removed from the surface and all cavities filled with a 1 : 1 mortar, thoroughly rubbed in and trowelled smooth. No plastering shall be applied.

(*d*) *Ageing.*—The concrete shall be allowed to harden at least thirty days, and longer if possible.

NOTE.—To assist in the setting of the concrete before it becomes oil soaked, it is advantageous to use several priming coats of a 1 : 4 solution of 40° Be. sodium silicate, followed by a finish coat of 1 : 2 solution. This forms a glazed surface on the concrete which, although it is not permanent, gives the concrete an opportunity to harden until the protection from the silicate of soda is no longer necessary.

4. LOCATION OF PIPE CONNECTIONS.

All pipe connections to the tank shall be made through the top.

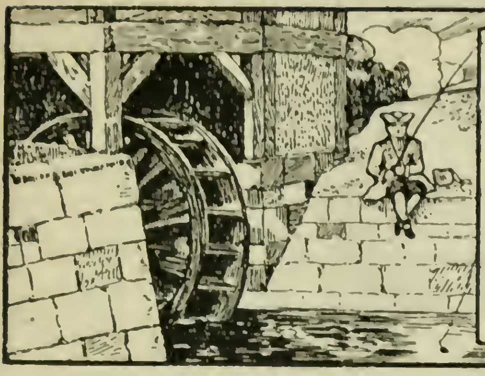
5. VENTING OF TANKS.

(*a*) Tanks shall be provided with a permanently open vent, or with a combined fill and vent fitting, so arranged that the fill-pipe cannot be opened without opening the vent-pipe.

(*b*) Vent openings shall be screened (30 by 30 brass mesh or equivalent) and shall provide sufficient area for allowing proper flow of liquid during the filling operation. Permanently open vent-pipes shall be provided with weatherproof hoods and terminate at a point at least 12 ft. above the top of the fill-pipe and never within less than 3 ft., measured horizontally and vertically, from any window or other building opening.

Where a battery of tanks is installed, vent-pipes may be run into a main header. Individual vent-pipes should, however, be screened between tank and header, and connection to the header should be not less than 1 ft. above the level of the top of the highest reservoir from which the tanks may be filled.

(*c*) Fill-pipe shall be screened, and when installed in the vicinity of a building shall not be located within 5 ft. of any door or other opening, and shall terminate in a metal box or casting provided with means for locking.



THE HOUSING PROBLEM.

SOME COTTAGES AT BRAINTREE.

We are indebted to the Unit Construction Co. for the following particulars and some of the illustrations shown here.—ED.

AMONG the various attempts that are being made at the present time to solve the housing problem, mention should be made of a pair of experimental cottages recently erected at Braintree in Essex by the Crittall Manufacturing Co. on the "Unit system." This system is primarily concerned with building to dimensions, the multiples of which are called "Units." These latter are constants, with the result that variations of dimensions are made in an exact ratio; so that an attempt has been made to standardise, not the cottage as a whole, but the method of its construction and building. The system is perhaps best explained by reference to the plan (*Fig.* 2).

In the case of the pair of cottages here described the unit adopted was 1 metre (for reasons which will be explained later), and in planning it was arranged that all walls were centred on unit lines, though the same could occur at $\frac{1}{2}$ or $\frac{1}{4}$ units if need be. The concrete blocks of which the walls are built measure $\frac{1}{2} \times \frac{1}{4} \times \frac{1}{8}$ unit, less the thickness of one joint each way. It therefore follows that if 2 blocks = 1 unit in length, and the wall so many more, it can be built without any cutting or waste. The same end can be obtained on plan with all the openings necessary for doors, windows, etc., if these are arranged with regard to the unit dimensions and the bonding of the blocks. If the same methods are adopted in the elevations of the walling, and courses arranged to work to unit dimensions, a series of openings are formed to receive fittings which can be made to exact sizes, or variations of the same, the ratio of which will be constant.

The metre was adopted as the unit for this first pair of cottages, because of the interest which is being taken at the moment in metrical measurement, and to see how far it could be employed by British workmen without complications resulting. As not a single workman on the job had any knowledge of metric measurements, the method adopted was to provide them with unit sticks, one metre long, divided into four parts, and with these they have been able to produce a building in which every dimension is metrical.

Plans have now also been prepared for other cottages, to be built to a unit of one English yard.

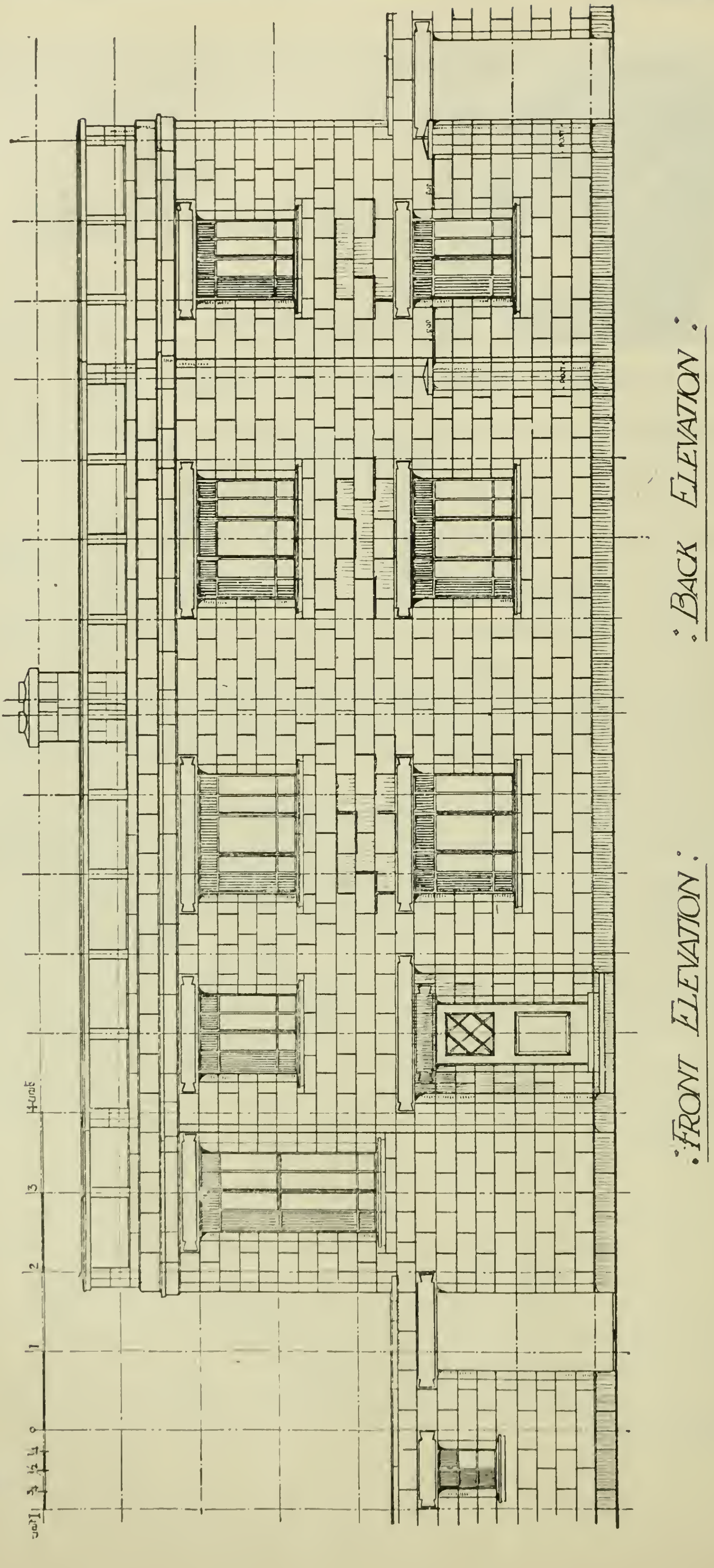


Fig. 1.
Concrete Cottages Braintree, Essex.

This plan shows the accommodation provided for the experimental pair of cottages and the aspect of the rooms. It illustrates as well the method of construction; how, by planning to unit dimensions, the blocks of which the walling is made can be assembled without cutting or waste.

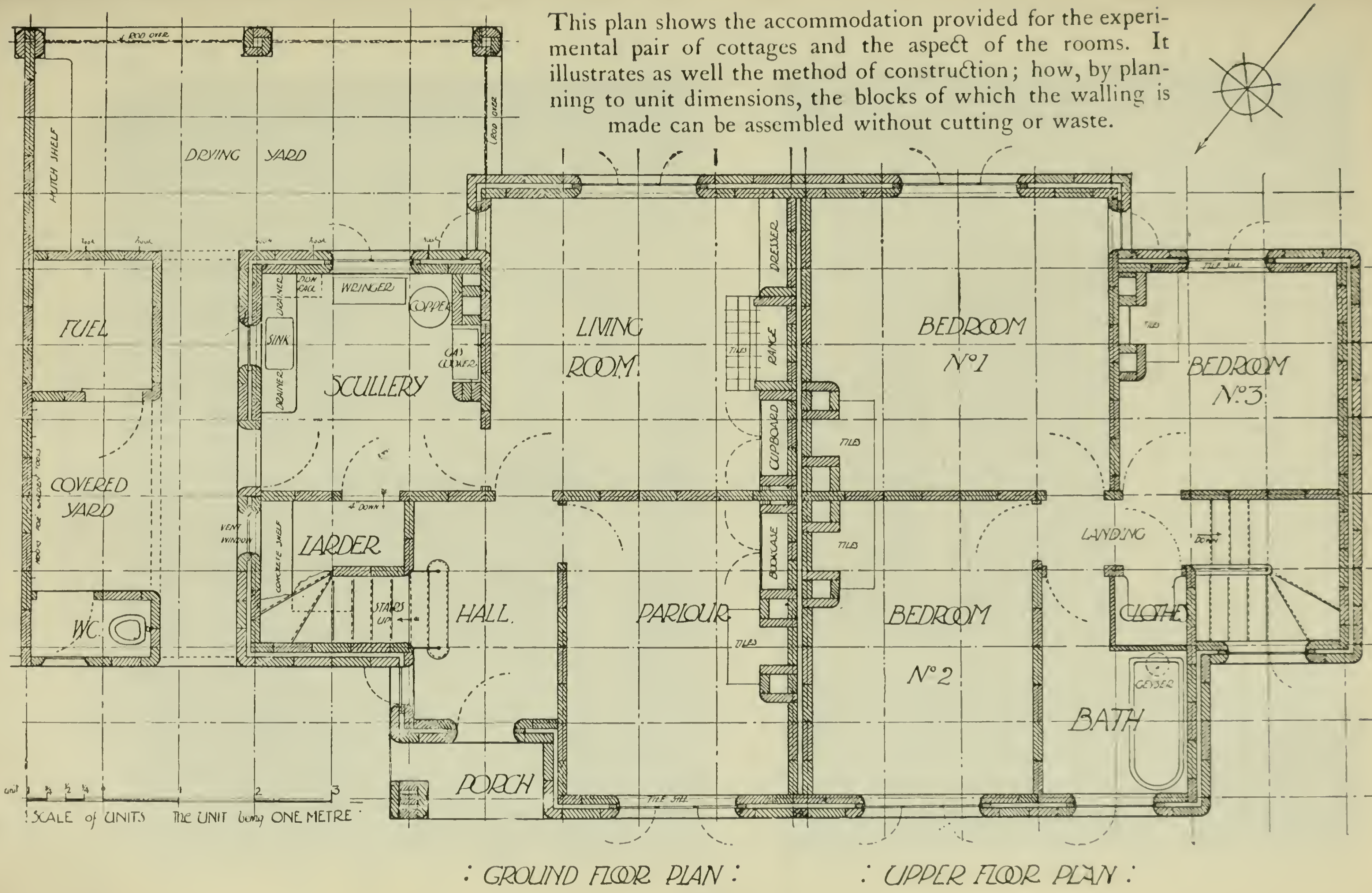


Fig. 2.

Concrete Cottages, Braintree, Essex.

The system is founded on the experience which the Crittall Company gained before the war as makers of casements, and since 1914 in the production of shells. In their opinion, if builders could be induced to adopt standard methods of building and sizes for the fittings, they and other manufacturers could produce the latter at prices which would be infinitely more favourable than anything which obtained before the war. This will not come about, though, so long as one man wants a casement of, say, 3 ft. 6 in. by 1 ft. 6 in. and the next customer insists on a size variation of ¼ in. each way. The same applies to all the other fittings of the house.

So far as housing is concerned, there is a very proper determination that the whole standard of living is to be improved and better accommodation provided, but the problem is that such improvements will have to be effected at a time when costs must be high.

Fine gravel being obtainable on the site, it was decided to use concrete blocks. The blocks were used as shown in *Fig.* 1. The same type of block was used for the partition as the external walls, and there can be no doubt of the stability of the construction. But, as has already been pointed out, had good bricks been easily obtainable, the same could have been employed, working to the yard unit. No timber or woodwork of any kind has been used. The floors and roof have been cast in concrete, reinforced with expanded metal, and experiments made with unit centering. So far as the roof is concerned, the unit system does not preclude the use of slated or tiled roofs. In the case of this pair of cottages flat roofs were used because it was felt to be advisable to make an attempt to overcome the prejudice with which this method is generally regarded. The roof concrete was composed of finely graded aggregate, and has been tarred on the surface. The windows are unit steel casements, and the elevation shows that by a combination of these it is possible to fill any sized opening which it may be required to glaze, subject to the fact that the same must conform to unit dimensions.

The exterior walls are 11 in. over all, and are composed of two blocks 4⅛ in. wide with an air space of 2¾ in.

The aggregate throughout was a 1 : 7 mix.

The interior walls on the lower floor are 4⅛ in. wide, and the joints between the blocks are ⅜ in. On the upper floor the partition walls are 2½ in. slabs.

The floors on the first floor are of concrete reinforced, 4½ in. thick, the floor finish being a jointless composite material, with rounded corners.

The roofing is a reinforced concrete slab. In future cottages a hollow air space will be introduced in the roof.

The walls on outside of the house are not rough cast, but the inside surface of the concrete blocks is plastered.

The hollow air space in the walls is continuous throughout the entire walls, and this will be connected with the air space in the roof so as to get a circulation of air right round the building.

The walls in some rooms are being finished with a thin coat of plaster, but the surface and appearance of the blocks is so pleasant, hard and durable, that it is not proposed to do so to the scullery and offices.

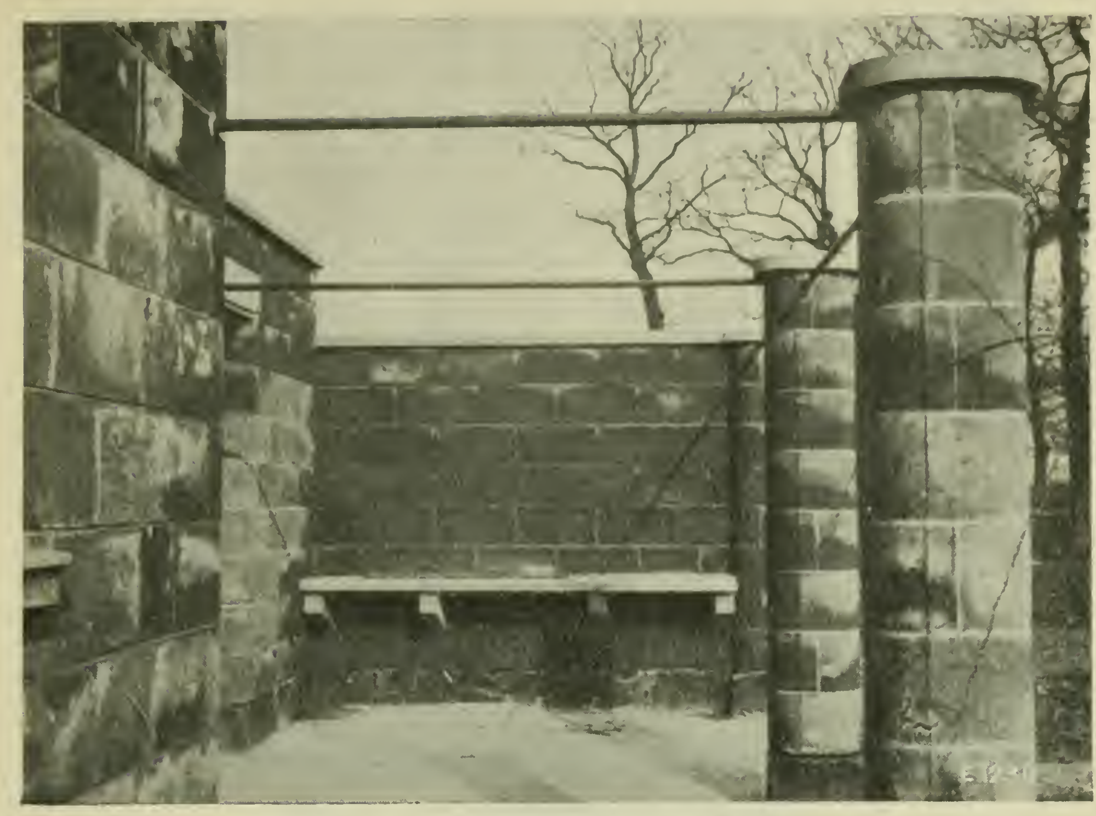
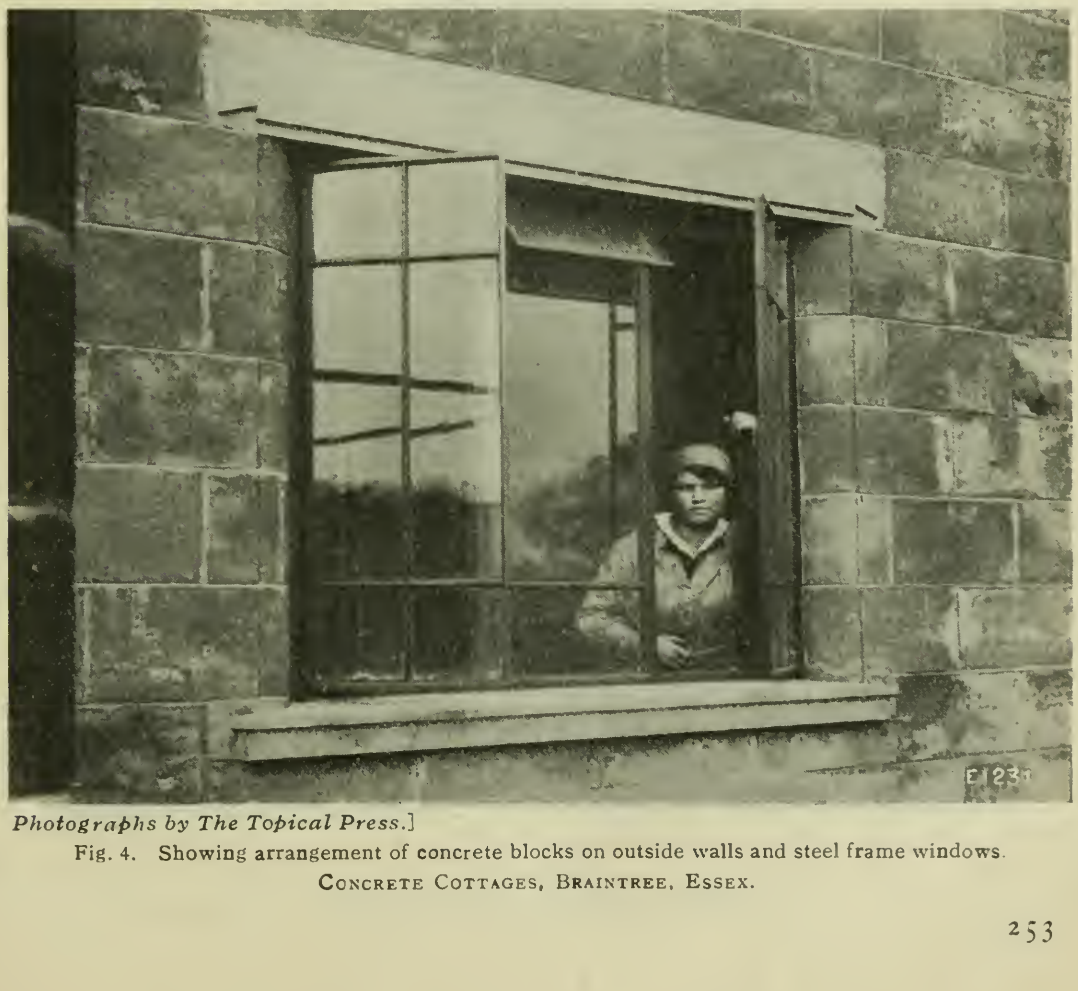


Fig. 3. Portion of garden set apart as drying ground, with line hooks and concrete shelves.



Photographs by The Topical Press.]

Fig. 4. Showing arrangement of concrete blocks on outside walls and steel frame windows.

Concrete Cottages, Braintree, Essex.

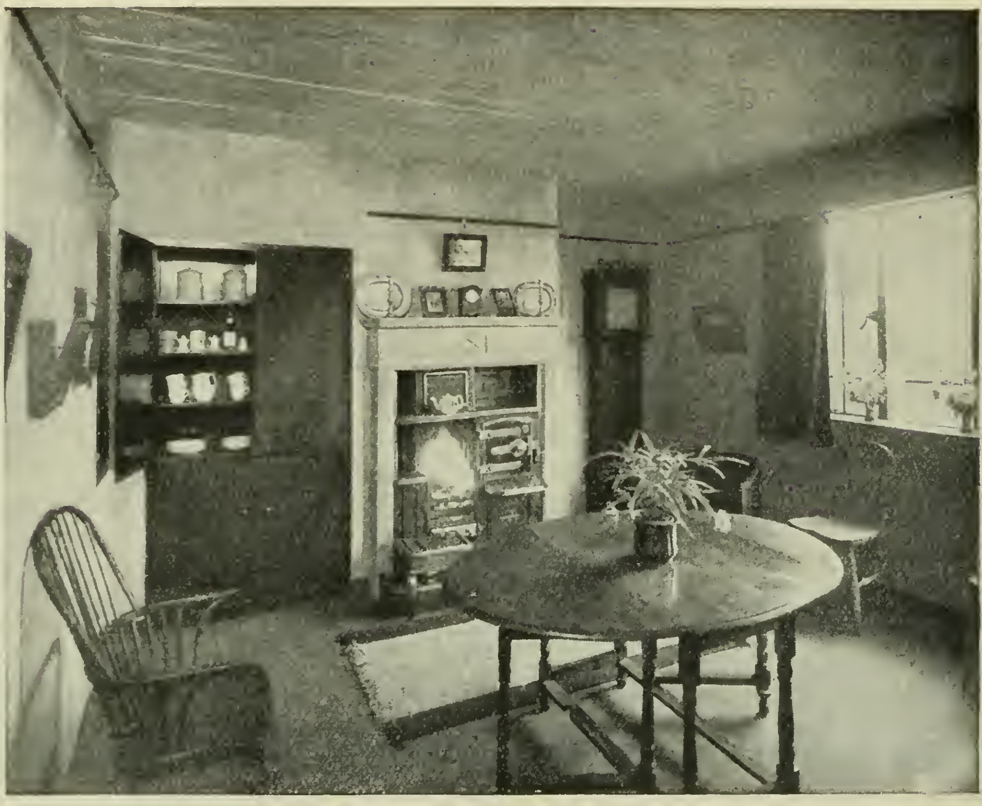


Fig. 5 Living Room.

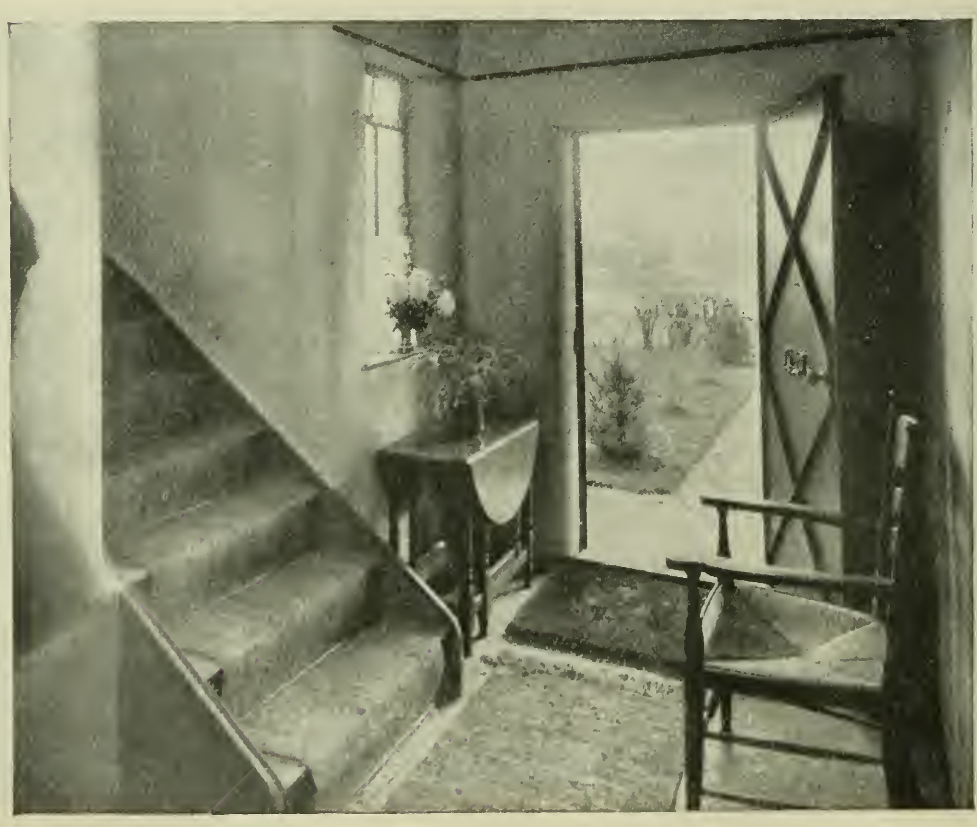


Fig. 6. Hall.
Concrete Cottages, Braintree, Essex.

Later, when plant is available, it is proposed to make the doors in pressed steel. Here again is an opportunity for an intelligent development of the country's resources. We shall leave off the war with a larger steel producing plant than has ever been the case before, and the price of fir framed in roofs is now 11s. 6d. per ft. cube. Sashes and frames which cost 1s. 2½d. per ft. super, now cost 3s. 8d. Doors have gone from 11d. to 2s. 8d. From the point of view of national economy, it would be desirable to attempt the use of the national product, steel, in lieu of the imported commodity, timber, which for many years must remain high in cost and inferior in quality.

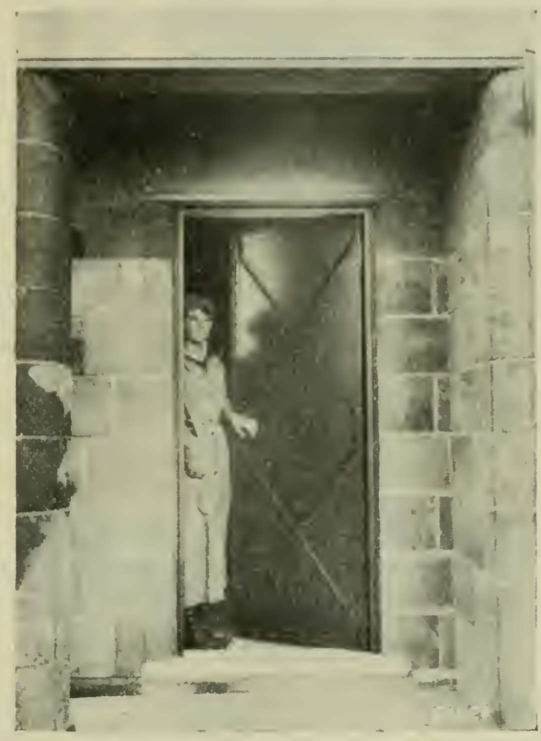


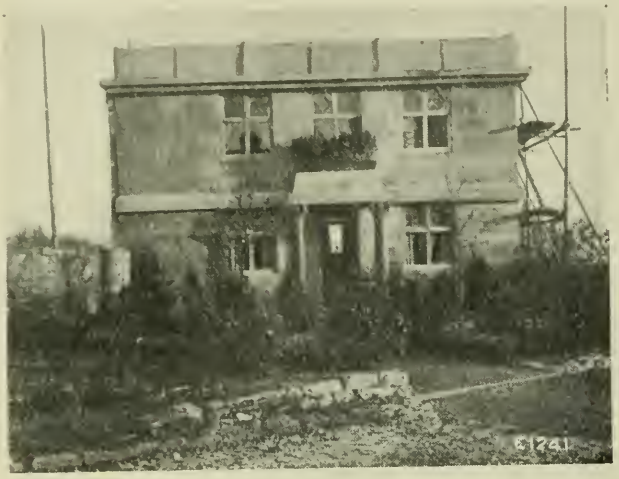
Fig. 7. Showing Steel Door.
Concrete Cottages, Braintree, Essex.

The system lends itself readily to planning and estimating. The architect in designing can rapidly estimate superficial areas and cubical contents. The plan illustrated (*Fig.* 2), for instance, contains, so far as the house is concerned, 49 super plan units. Such basis is a very valuable help in planning and also lends itself readily to estimates of costs and actual pricing of construction. The actual cost of these cottages is considerably less than the cost of cottages with the same accommodation built in brick on the ordinary methods.

In conclusion, we would add that Mr. C. H. B. Quennell, F.R.I.B.A., acted as architect, in conjunction with Mr. W. F. Crittall, and Mr. Wm. Matson acted as clerk of works. The Unit Construction Co., 246 High Holborn, are developing this method of construction, and are building a large number of houses of various sizes and types on the Unit principle.

Evidence was given before various committees, of which Sir Tudor Walter's was one, and, consent being obtained, the cottages were started on July 30th last.

A certain prejudice had to be overcome at the start, but the men at work speedily became interested in the experiment. The Labour Party and the local Trades Council have also shown a very friendly interest.



A CONCRETE HOUSE AT HARPFIELD, STOKE-ON-TRENT.

By G. W. HILTON, Architect and Surveyor, Harpfield Estate, Stoke-on-Trent.

The following is a description of how the Author, largely by his own labour, erected and completed a concrete mono-bloc house for his own occupation. It is an example of the application of concrete for house building, not only as far as the actual walls are concerned, but it is interesting to note its use for fire-places, kitchen shelving, staircase, etc.—ED.

PREVIOUS to the necessity arising during the war for my providing a home for my family I had undervalued cement as a building material, looking upon it only as an accessory to remedy the defects that most other building materials are liable to.

After a theoretical study I came to the conclusion that if cement were placed at its true worth and given the position of first importance in a building, every other necessary material being made subservient to it, a better building would result.

I commenced by selecting the most suitable and accessible aggregate—viz., refuse destructor clinker. This was tried in several sizes and finally ½ in. was adopted and allowed to weather as long as possible before use. The concrete was mixed in the proportion of 1 of cement, 3 of pit sand and 8 of clinker, for walling. For floors, roof, shelving, stairs, etc., a 1 : 2 : 4 mix was used.

For shuttering, several large plate-glass cases, constructed of deal-butted boards ¾ in. thick and 4 in. by 2 in. stretchers, average 2 ft. apart, were acquired. From these sets of shuttering were formed consisting of one large sheet 8 ft. square to take the inside position for downstairs walling and the outside for upstairs. When fixed for depositing concrete this board had its bands vertical, but the reverse board, which was cut to climb the 8 ft. in four lifts, had its bands horizontal. The minimum thickness for outside wall of 9 in. was maintained by means of concrete bricks and maximum space by means of ⅜ in. pins, with screwed ends fitted with nuts and washers. These were capable of being withdrawn, but the bricks remained in the work.

After forming double thickness footings on firm ground the outside wall was carried up by means of planks to dampcourse height. This was formed of pudloed

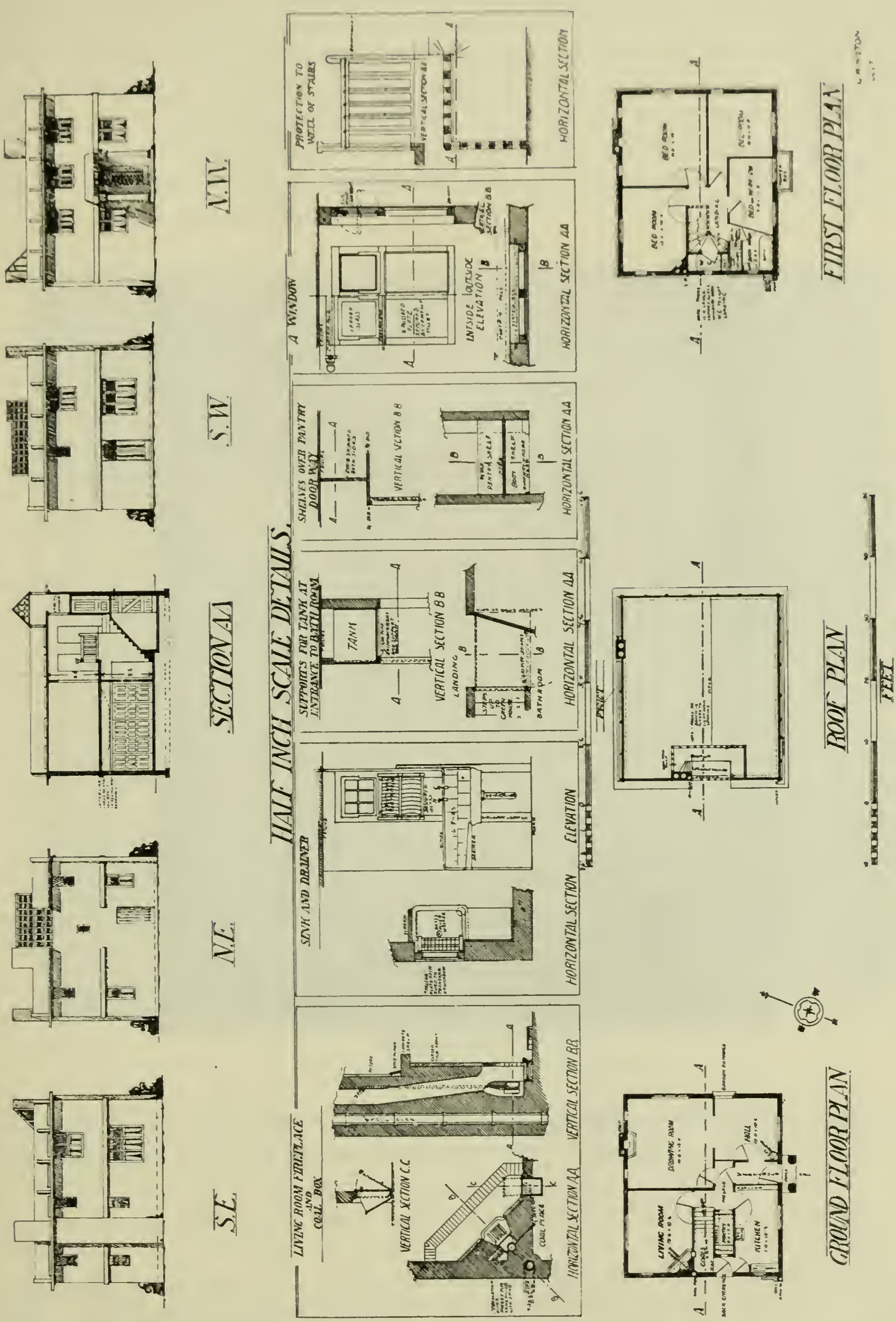


Fig. 1.
A Concrete House at Harpfield.

D

cement and sand 1 in. thick. After concreting 4 in. thick the whole of the area contained by outer wall, the forms as already described were erected on one corner and concrete deposited until height of underside of window head. From a corner it was always found to be possible to reach the nearest window or door opening side, and a 9 in. by $1\frac{1}{4}$ in. board of suitable length was screwed to large sheet in correct position. After repeating at an adjoining corner the remaining space was filled in, and so on until the whole of outside walling was complete.

Fireplaces, which were also concrete and faced with glazed tiles, were formed by means of a box placed in shuttering and flues carried up by means of 6 in. drain pipes, which were drawn up as work proceeded, leaving a clearly defined circular flue $7\frac{1}{2}$ in. in diameter. The fireplaces are all found to stand the fire well. The mantelshelf is of concrete *in situ*.

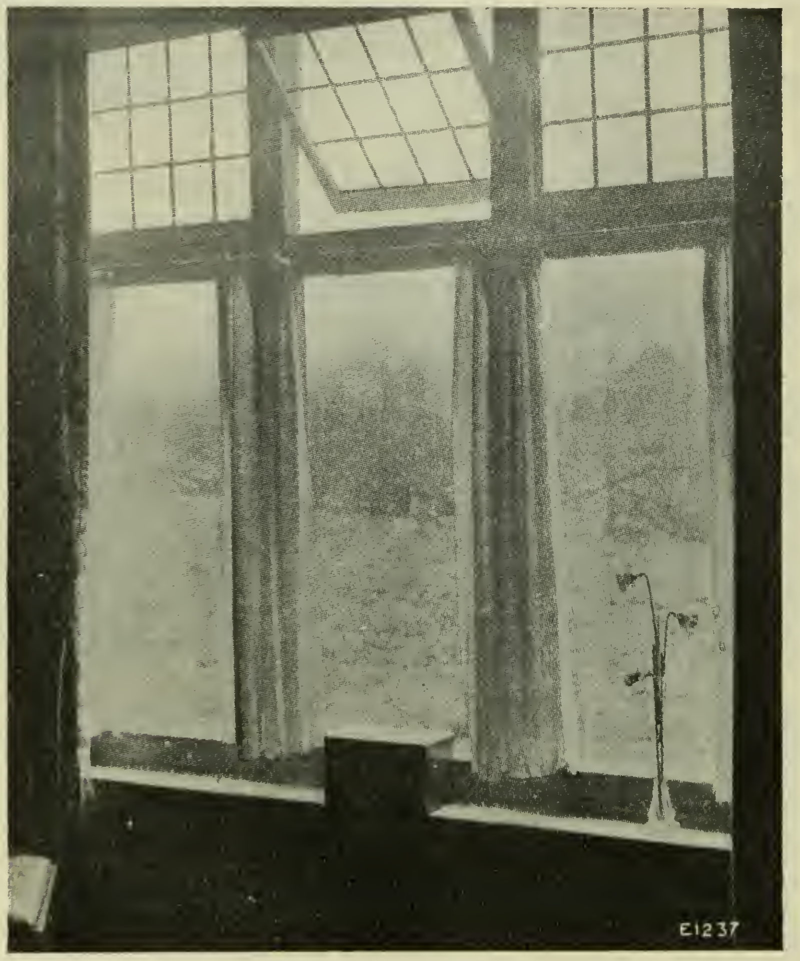


Fig. 2. Window details.
A CONCRETE HOUSE AT HARPFIELD

Soil pipes and rain-water down pipes and drain pipes were placed as the work proceeded.

The inner weight-bearing $4\frac{1}{2}$ in. walls were next constructed by using the same sheets and subsequently using them again as shuttering for floors. The concrete was laid 5 in. thick and reinforced at 7 in. intervals with $\frac{3}{8}$ in. rods on lower side.

Next the stairs were formed by means of a spandril board and 7½ in. boards for risers. The stairs were reinforced with two ⅜ in. rods in each step and the curved spandril had the addition of "Hyrib," which also formed a good centering.

The work on the upper storey was a repetition of the lower, and the roof a repetition of floor except that a 6 in. slope to N.W. and S.E. sides respectively was formed. The screen wall round roof was reinforced with fowl netting, first secured by being run through the centres of circular pillars, which were in their turn reinforced by ½ in. rods previously fixed in roof work. The screen wall was completed by filling in boards 3 in. apart.

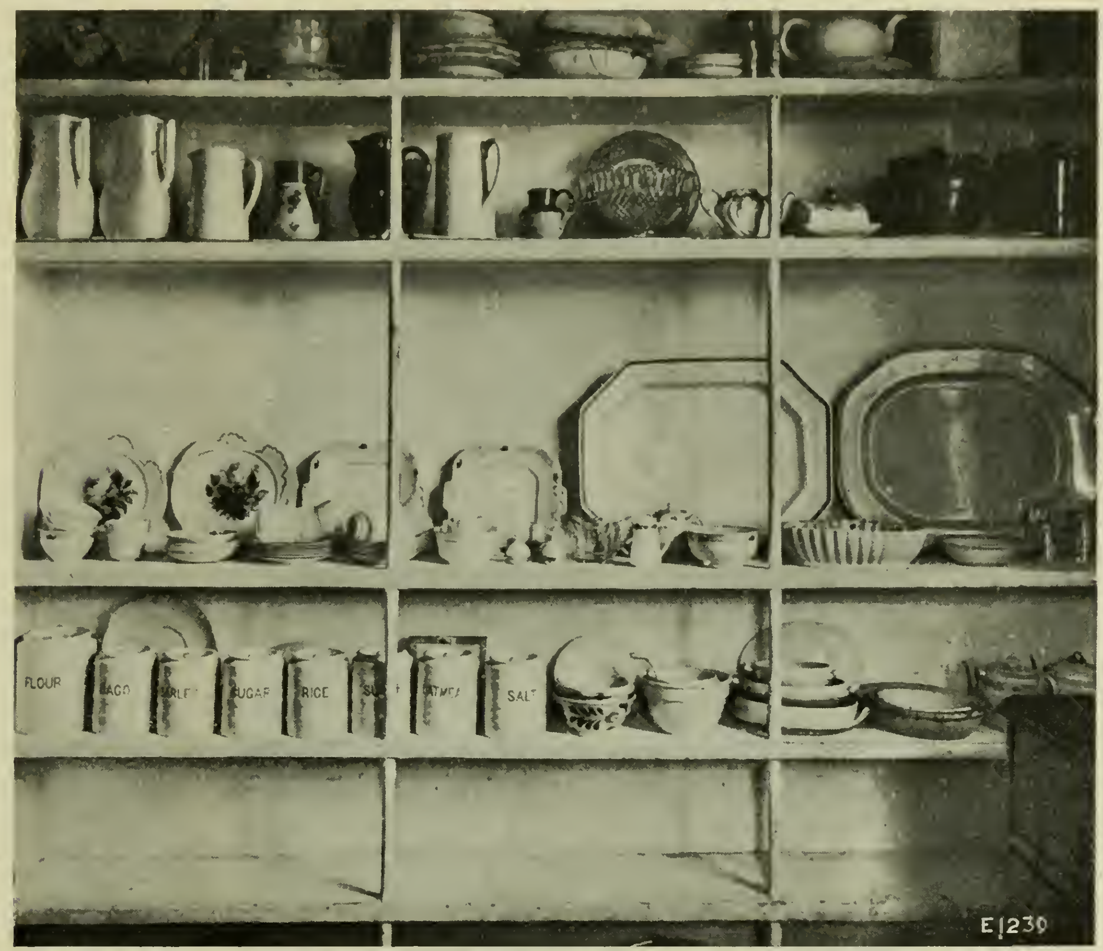


Fig. 3. Showing Concrete Shelving.
A CONCRETE HOUSE AT HARPFIELD.

Most of the greenhouse framing was carried out on similar lines, as was also the protection on stairs, the resulting spaces being secured by means of insertion of bricks or wood and subsequent removal.

Generally speaking, three sets of wall forms are sufficient to erect a house of this size, and forms may be taken away 18 hours after depositing, and 8 days from under floors or roof. The forms may be used an indefinite number of times, as by a carefully considered system of overlapping of completed work by the forms and a well preconceived means of withdrawing large sheets from inside the house very little cutting is required.

The windows were constructed by casting each separate member in a box made to give a 3½ in. by 3½ in. by 6 ft. casting ; the different rebates were formed by the placing of suitably shaped and sized strips in the box.

The provision for hanging of casements, as shown on detail drawing, is worthy of notice. It was found that the cleanest castings resulted after coating the box with oil paint. This is much better than any kind of grease or oil, these materials being inclined to press into the body of the soft concrete and to spoil the setting of the concrete in certain parts. The skimming to both inside and outside was of cement, lime, putty, and sand, previously washed, and, in the case of outside, dyed slightly with ochre. Skimming was finished with a wood float giving a good receiving surface for distemper or coloured liquid cement. The only woodwork was in doors or panelling, in which case it was home-grown oak brown in colour.

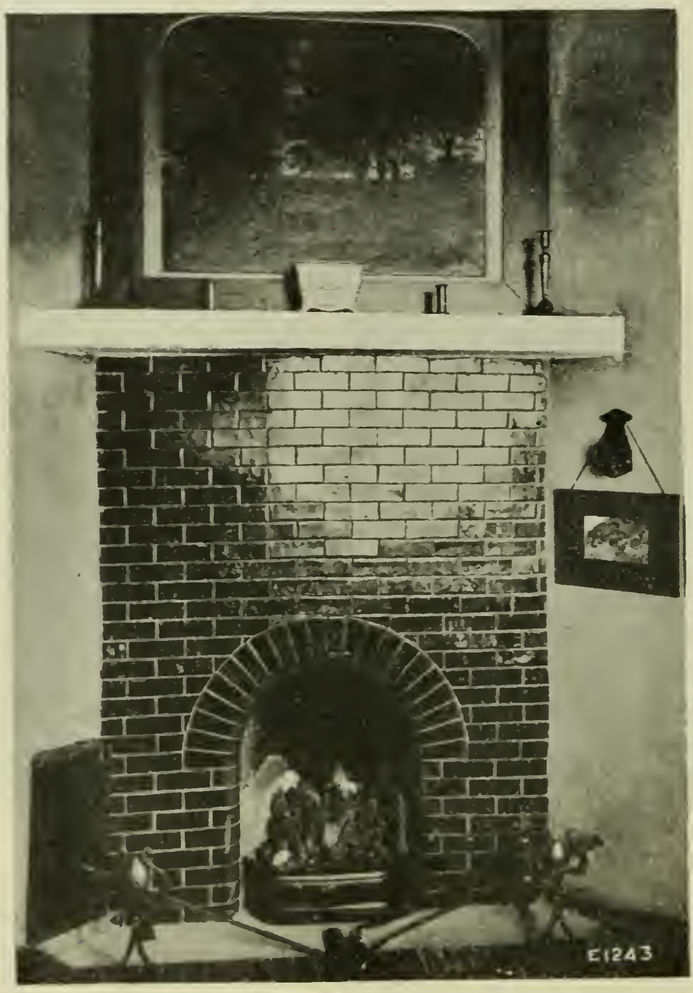


Fig. 4. Showing Concrete Fireplace faced with glazed tiles
A Concrete House at Harpfield.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRBTE INSTITUTE.

REINFORCED CONCRETE SHIPS.

By J. S. E. DE VESIAN, M.I.Mech.E.

The following is an abstract from a paper read before the Concrete Institute on March 27th. The President, Mr. H. D. Searles-Wood, F.R.I.B.A., was in the Chair. A number o interesting lantern slides were shown to illustrate the paper.

THE concrete ship has arrived and has undoubtedly come to stay.

The latest type of naval vessel, the submarine, is no doubt largely responsible for the rapid advent of the concrete ship ; if tonnage had not been required so badly it is possible the Admiralty would not have contemplated a programme of reinforced concrete ship construction, which has given an opportunity to designers and builders to gain experience and thus place this new industry firmly on its feet.

Much has been written on the subject of concrete ships during the last twelve months and a dozen or so vessels of 1,000 tons have been launched. Up to this time attempts had been made with varying success to produce small boats or lighters and barges, but no serious attempt to construct a sea-going vessel had been made. It is intended in this paper to endeavour to show the evolution of methods of construction for concrete ships and in particular that method known as monolithic in contradistinction to the unit systems. The boldest experiment in this direction was carried out in the United States in the building of a vessel called the *Faith*, which, like her prototype in steel ship construction the *Great Eastern*, has been a success, but was before her time. The details and performance of this ship have been widely published and the experience gained of great value.

All reinforced concrete ships built up to now have been heavier than steel ships of equal dimensions, and this fact has been used as the great argument against their successful competition with steel vessels ; but it must not be forgotten that the cubic capacity is greater and therefore for light cargoes, such as fruit, cotton, jute, Eastern goods, wine, etc., they can carry larger cargoes than the steel ship, and if used in such trades, which represent a very important part of our imports, the concrete ship would prove to be economical and advantageous. To-day valuable fruit cargoes are carried on deck owing to lack of capacity below, and heavy losses are incurred through damage by sea water which would be avoided if carried in a reinforced concrete vessel.

The design of steel ships is largely empirical, and this is so because, while it may be easy to calculate the stresses to which a vessel will be subjected in still water, it becomes well nigh impossible to compute accurately the effects of the torsional and racking strains, etc., which a vessel suffers in a sea way. Various rules have been laid down by the classification societies which embody the result of long experience gained through the classification and survey of ships for many years past, and in studying the design of concrete ships it was felt that one could only "translate" into reinforced concrete the strains which it had been customary to work to in connection with steel ships.

The rules of the classification societies of Lloyds Register of Foreign Shipping and the British Corporation for the Survey of Shipping provide for vessels such as now under construction being designed to meet certain conditions. The first condition is that the vessel is assumed to be suspended between two wave crests, the length between the crests being equal to the length of the ship between perpendiculars and the depth of the wave being taken at 1/20th of the ship. This condition is termed sagging. The alternative condition, namely, hogging, takes place when the ship is assumed to be supported amidships on a crest of the same theoretical wave, and obviously in this case the ship as a whole acts as a cantilever. It will be obvious that when a ship is in a sea way the deck and bottom of the vessel will be alternatively in tension and compression, and there will be other strains which have to be allowed for in the design of the reinforced concrete work. It naturally follows that practical considerations govern the design to a certain extent and this applies both to steel vessels and concrete vessels. In the former, for practical reasons, the structural steel work is not used to the most economical advantage in vessels of small tonnage, and the same reason applies to the concrete used in the reinforced concrete vessels. While it may be possible from a theoretical point of view to have a thickness of, say, two inches of concrete, such a thickness would not be recommended by one having practical knowledge of the difficulties involved in the proper manufacture of a watertight concrete of this thickness.

The remarks in this paper as to vessels now under construction relate to the barges and tugs ordered towards the end of 1917 by the Deputy Controller of Auxiliary Shipbuilding, which department is now under the control of the Ministry of Shipping, and also in connection with the design and construction of some steamers which the Ferro-Concrete Ship Construction Co. decided to lay down as an experiment prior to the commencement of the Government programme.

The first of these steamships, ss. *Armistice*, left Barrow on January 7th of this year on a voyage to Londonderry, where she was loaded with 1,000 tons of oats in bulk, and sailed from there to London. Very severe weather indeed was encountered, many steel ships put in damaged, but the vessel successfully withstood the trial and brought her cargo in perfect condition to London and sustained no damage whatever herself.

As regards the barges and tugs building for the Government, the leading dimensions of these are as follows :—

BARGES.

Length between perpendiculars	180 ft.
Breadth	31 ft. 6 in.
Depth	19 ft. 6 in.
Draft loaded	8 ft.

TUGS.

Length between perpendiculars	125 ft.
Length overall	132 ft. 9 in.
Breadth on 12 ft. water line	27 ft. 6 in.
Depth	14 ft. 9 in.
Draft—mean	12 ft.

The cost of the first vessels from each yard has naturally been high, in fact considerably higher than the cost of a similar vessel in steel. This is largely due to the question of timber moulds. Subsequent vessels from the same moulds have cost considerably less, and as duplication is increased and the labour market improves the cost will come down more and more.

The first contracts let by the Admiralty were for some 200 (odd) vessels of two types—1,000 tons d.w. dumb barges and for steam tugs of 750 h.p. These orders were entrusted to various firms, some established shipbuilding companies, and others established for the purpose of their construction. Various designs were employed, some firms working on what is known as the unit system, pre-casting separate portions of the vessel and building these portions into the fabric ; and others on the monolithic system, making moulds and working the concrete and steel *in situ*. The former method was adopted by Messrs. Concrete Seacraft, Ltd., at Fiddlers Ferry ; Messrs. Hughes and Stirling, at Preston ; Messrs. Blacketts Concrete Ship Co., at Darlington ;

Messrs. Stuarts Concrete Ship Co., on the Thames; Messrs. Christiani and Nielsen, at Tilbury; and the latter method was adopted by Messrs. Hill, Richards and Co., of Poole, who designed the dumb barges on a special method with double skins. Messrs. The Aberdeen Concrete Shipbuilding Co., The Scottish Concrete Ship Co., Amble Ferro-Concrete Co., Gloucester Ferro-Concrete Shipbuilding Co., British Construction Co., Queenborough Shipbuilding Co., J. and R. Thompson, Ltd., of Warrenpoint, in Ireland, and the Ferro-Concrete Ship Construction Co. adopted the single skin monolithic type from the designs of the author's firm.

Six months before the order for these dumb barges had been given by the Admiralty the Inland Water Transport Department had entrusted Messrs. Stewart and Partners with the construction of two 500 ton d.w. barges, and these vessels were constructed by them at Brentford, and are now in service.

The first of the 1,000 ton barges to be launched was from the yard of Messrs. Hill, Richards and Co., at Poole, August, 1918. This vessel was rapidly followed by launches from Barrow-in-Furness and Barnstaple yards on the 21st September. Since that time nine further vessels have been launched, and two from the yard at Poole, the double skin design being discarded now in favour of the single skin monolithic type at that yard.

While the double skinned boats carried only 780 tons, the first 1,000 ton boat from Barrow was capable of carrying 950 tons, and subsequent vessels rather more. These dumb barges have been in service carrying goods between Southampton and Havre on Government service, and have received consistently satisfactory reports from the officials deputed to report on them.

The concrete vessel from which the most useful data will undoubtedly be obtained for guidance in the design of future vessels is the ss. *Armistice*, launched at Barrow.

The leading dimensions of the boat are given below as well as the corresponding particulars for a steel vessel of the same d.w. carrying capacity.

		Concrete.		Steel.
Length between perpendiculars		205 ft.		188 ft.
Breadth moulded		32 ft.		30 ft. 3 in.
Depth moulded		19 ft. 6 in.		17 ft. 3 in.
Draft when loaded		15 ft. 6 in.		14 ft. 6 in.
Dead weight		1,150 tons		1,150 tons.
Displacement		2,350 tons		1,800 tons.
Indicated horse-power	(about)	400	(about)	400
Speed	(about)	7¾ knots	(about)	7¾ knots.

The quantity of concrete employed in the vessel was 500 cu. yd. and the total weight of steel about 190 tons. The steel is about 42½ per cent. of the weight that would have been required for a steel ship.

Owing to the greater displacement of the concrete vessel the fittings and equipment generally were required by the registration societies to be of a somewhat heavier type, and also, naturally, many of the castings had to be specially designed to permit of their attachment to the concrete work, and this question is somewhat more intricate than in the case of steel vessels. After the first voyages the hull was in a perfectly satisfactory condition.

Materials.—The author does not propose to deal exhaustively with the physical qualities of concrete materials, members being well acquainted with the requirements to produce the strongest and most impermeable concrete which in ships do not vary from the best practice in ordinary land structures. The proportions of voids in both aggregate and sand must be carefully ascertained and the grading and quantities of the components of the mixture proportioned accordingly, care being taken to ensure an excess of cement paste over that necessary to fill the voids in the sand, and an excess of mortar over that necessary to fill the voids in the aggregate. Owing to the scantlings in a ship being reduced to a minimum to save weight the aggregate must be somewhat finer, *i.e.*, broken to a smaller gauge than is usual with buildings and engineering structures, and it follows therefore that the voids will be greater.

The author's firm eventually adopted the following proportions for the concrete:—

Aggregate broken to pass ½ in. gauge, *i.e.*, ⅝ in. to ¼ in. free from smaller particles and dust	27 cu. ft.
Sand ⅛ in. to dust	13½ cu. ft.
Cement	8½ cwt.

These proportions will apply so long as the percentage of voids in the aggregate does not exceed 50 per cent. When the voids are greater a corresponding extra quantity of sand and cement must be added.

As regards the shuttering for monolithic vessels, this was designed substantially on the usual lines, but special arrangements were made to permit of the removal of the shuttering when the concrete had set, and its rapid re-erection for succeeding vessels.

With a view to economy in the cost of shuttering work and speed of erection it was decided to keep the lines of the ship as straight as possible, and to this end, in the case of the Admiralty dumb barges, a simple midship section was adopted, with straight sides and bottoms and a very small radius at the bilge. For half the length of the vessels amidships the aforementioned section obtained. The bow and stern had, of course, to be shaped, but here straight line sections were maintained as far as possible.

The author, however, is of opinion that from the experience so far gained in the erection of the shuttering for vessels built it would be a comparatively simple matter to arrange the shuttering for a vessel built with the usual curved lines.

At the commencement of the programme, when timber was very difficult to obtain, a system of steel shuttering was initiated, there being a large amount of steel sheets available, and this system has proved quite satisfactory. The steel plates were built up in panels stiffened with timber and bolted together, and capable of being re-used a vary large number of times. This question has received considerable attention, and a new form of shuttering has been evolved by Mr. F. Brazendale and patented by him, which the author considers a decided advance. The method is described as follows :—

When shuttering is constructed in panels the whole height of the vessel, these panels are of a convenient width to take standard sheet iron. The frames supporting the iron sheeting are of light section steel work bolted together to form a continuous mould and capable of being moved up to and away from the steel skeleton of the vessel. When the moulds are made of timber and the steel work afterwards assembled great difficulty is experienced in setting the steel, and with this method it is proposed to erect the floors and frames as complete skeletons, the component parts being wired or welded to one another so as to form rigid members, the frames being set up and the lines faired, the steel work of the skin of the ship being complete without any shuttering to interfere with the work, so that it may be handled from both sides, which is impossible when a wood mould is first erected. After the steel skeleton is completed the panels of shuttering are moved up into position the correct distance away from the skeleton and bolted together to form a continuous mould, the internal shuttering being erected lift by lift as usual with timber or sheet iron panels.

With this method, therefore, the shuttering need only be in position for just so much time as is necessary for getting the concrete in, and can be moved away directly the concrete has set sufficiently to support itself, and taken to a fresh slip and used again.

If this method of shuttering is used in conjunction with an improved method of making the bottom and floors, a great saving will be effected in the time of construction and cost.

In making the bottom a flat sheeting of timber in panels is provided, the bottom steel being placed in position arranged in such a way as to enable it to be efficiently joined to the floors after the bottom has set. With this method a clear flat run of floor can be made just like the floor of an ordinary building, and the bottom concrete being set, the floors with part of the frames which composes the bottom of the ship can be lifted bodily into position as a rigid skeleton. The shuttering for these floors can then be easily placed in position on the finished concrete floor and the floors concreted easily and without danger of dirt or hollow places being left owing to the difficulty of getting the concrete in if it is attempted to concrete the whole of this part of the structure at once.

In a paper read by Mr. T. J. Gueritte before the North-East Coast Institution of Engineers and Shipbuilders in March of last year he gave a number of interesting figures in connection with the weight of reinforced concrete vessels in comparison with steel. These figures the author considers from his experience to be very fairly accurate, and, if anything, rather too high. But as previously stated, it must always be kept in mind that the greater cubic contents of a reinforced concrete ship compared with an equal d.w. carrying capacity exceed that of steel vessels and for all bulk cargoes the concrete ship will have the advantage over its steel rival.

Hysteresis.—The author discovered that the use of ordinary mild steel bars with an ultimate tensile strength, say, at rupture of about 63,000 lb. and the yield point corresponding to about 32,000 lb. per sq. in., accounts for a large part of the slight sagging which is noticed in reinforced concrete structures after they have been loaded or stressed for the first time. This sagging does not increase by subsequent stressing, and in order to obviate the appearance of such sagging, engineers or architects are in the habit of specifying that the beams should be moulded with a slight camber. The author considers that this initial sagging is due mostly to the phenomenon of initial permanent set, or "hysteresis," to borrow the term used by electricians to denote a similar phenomenon observed in their sphere of knowledge; and it is also exhibited by ordinary steel structures when stressed for the first time. In the case of reinforced concrete, however, this initial set causes initial stresses in the surrounding concrete, and although less important in the case of ordinary building construction if proper factors of safety are allowed, in structures like ships where alternating stresses occur through hogging and sagging, the initial permanent set in the steel produces a somewhat unelastic state in the structure which is detrimental and materially increases the tendency of cracking of the concrete, which for obvious reasons must be avoided in ships.

The author's firm therefore decided to adopt a form of bar of which they had had previous satisfactory experience. These bars are made from ordinary mild steel and are more or less triangular in section with rounded corners. They are subjected to a special process of twisting, the effect of which is to produce in the bar that initial permanent set which would take place in a plain bar when first loaded. This twisting has also the effect of producing an efficient continuous bond and increases the elastic limit with a proportionately less elongation under calculated stresses.

Previous mention has been made of a method of construction called the "unit" method, whereby the ships are built of pre-cast sections. It is very difficult for the author to express any views on the matter, as only one vessel of the Admiralty programme is at the present time afloat which has been carried out on this method of construction. From the author's experience generally he doubts the expediency of attempting to build sea-going ships in this manner.

DISCUSSION.

Mr. S. Bylander, in opening the discussion, said the Paper was worthy of the Institute, as being, he believed, the first Paper on reinforced concrete ships. It might be interesting to note that in America the lake steamers and lake transport barges were practically all launched broadside. The arrangements were similar to those described in the Paper. He noticed there was one difference between the reinforcement of the *Faith* and that of the *Armistice*; in the former ship the reinforcement in the skin was laid diagonally, and in the latter vertically and horizontally. The concreting for some of the American ships had been made flush with the reinforcement, and a cover put on afterwards with cement. He understood that the concreting was done in one operation. Would the author explain whether there was a marked difference in skin friction between a reinforced concrete ship and a steel ship? Personally he thought that the coating of concrete would be an advantage in reducing the skin friction, which was the principal resistance for a ship of slow speed.

Mr. J. Turner Morris, as one who had had some practical experience in reinforced concrete shipbuilding, said that the monolithic system of concreting would certainly appear to be structurally preferable and more watertight as compared with the unit system, but his experience was that in practice the concreting of any vessel took not less than three months, therefore the monolithic advantage was somewhat lost, owing to the long intervals in the process of concreting. These intervals resulted in "sawdust joints," owing to the difficulty, or impossibility, of cleaning out all the rust and sawdust, etc., even with a hose or by hand labour, thus causing extra expense and increasing the time of construction, as they had to be cut out and made good before the vessel could be launched.

Experience had shown that concrete boats might develop, under stress of weather, deck cracks at the junction points which marked the intervals in the process of concreting.

With regard to the size of the aggregate adopted by Mr. De Vesian's firm, he noted that it was ⅝-in. down, whereas ⅔-in. down was, he believed, the size required by Lloyd's Register because of the small thickness of concrete covering.

Referring to the shuttering patented by Mr. Brazendale, the speaker said that obviously it was uneconomical to fit wood shuttering at heights of 6-in. both inside and out, while joiners and shipwrights were working at quarter speed. The difficulty of concreting in the confined space resulted in slow progress in the building of the sides and ends of the boat, and some system of working joiners, steel-fixers and concreters in periodical shifts was necessary if the time occupied in the construction of steel ships was to compare favourably with that in the case of steel ships.

He would like the author to describe how he treated the relative rigidity of a frame to the floor.

Reinforced concrete ships had not yet had a fair chance, since just as they were being turned out at a reasonable rate the construction was stopped. Thus the cost of the outlay of the yards and several sets of complete shuttering, as well as the costly experience of training indifferent labour for a new type of industry, had to be charged up to two or three vessels per yard. The *Armistice* was no guide to the probable cost of such craft. If, instead of one, twenty such vessels were built, under efficient management, with standardised methods, which included bending as many bars as possible at the steel works, the cost of each might be 30–40 per cent. of the cost of the *Armistice*.

Had the author any evidence to support an increase of allowable stress on the concrete, or any proposals for a light weight concrete similar to that used in America? Granite concrete weighing 150 lb. per cu. ft. was hardly suitable in comparison with the light weight of the American concrete. Much difficulty was experienced in obtaining both the crushing strength and the satisfactory percolation results in British yards. There was little danger for a reinforced concrete vessel afloat or at sea, but a serious possibility of the bottom crushing if resting on an uneven river or wharf bottom owing to rigidity of the material.

Mr. Ewart S. Andrews, B.Sc. said it would be rather premature to infer that the costs of the experimental ships would prevent the construction of reinforced concrete ships developing into a regular industry. The point to be settled before the future of the industry was established was whether reinforced concrete boats were as satisfactory as steel, and whether the increased cost at present could be set off against the apparent diminution in cost in the future. At present they were not in a position to say what would be the cost of a reinforced concrete ship on a production basis.

A point that appealed to him strongly was the use of what was known scientifically as overstrained steel. Such steel was not allowed under the London County Council Regulations, probably because it would not comply with the British Standard Specification, but the question was frequently raised whether overstrained steel was safe. That was a point which the Institute might very well take up. He thought the time had come when they should no longer insist on a dead mild steel for structural work; with proper safeguards, a treated steel, which would give a higher yield point, should be allowed to be used, with a high working stress.

Mr. G. B. Hall (The Ferro-Concrete Ship Construction Company), replying to the point raised by Mr. Bylander, said that the skin friction or skin resistance was practically the same in the case of a reinforced concrete ship and a steel ship. The steel surface was smooth, but there were laps and rivet heads to contend with; the concrete surface was slightly rougher, but had no laps or rivet heads.

Mr. W. A. Green, M.A., said he made some interesting experiments some years ago, stressing steel up to the drop of the beam and shutting off the load, leaving the bar for a day, and next day taking it right past the same load that stretched it before. In that way the bar could be turned down to the next section and stretched again. It was impossible to get it stretched again at the place where it had once stretched.

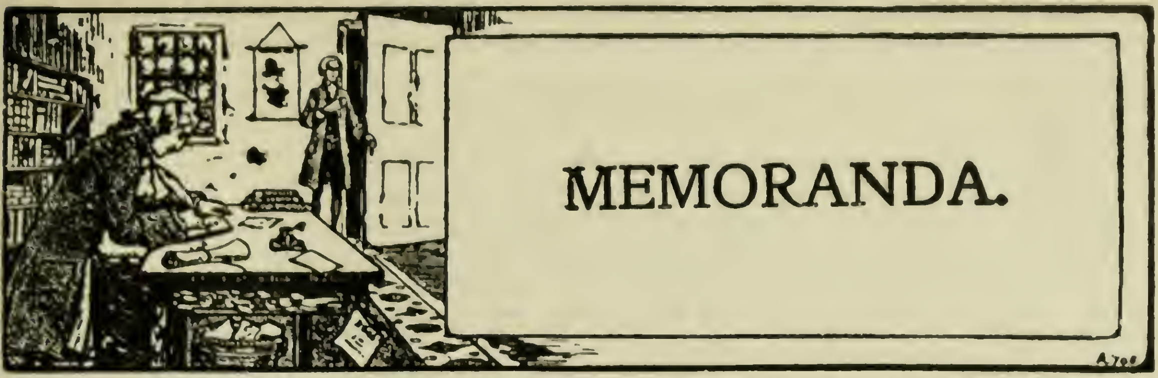
THE LECTURER'S REPLY.

The author, in his reply, referred to the question of moulding the concrete in one thickness, or moulding it up to the edge of the bar and rendering it outside. He was very much opposed to any form of rendering or plastering in reinforced concrete work; the same results were never obtained from a rendering as from a solid moulding, and his firm had always kept to the practice of moulding the concrete between moulds to give the necessary covering to the steel in one operation. It was their wish, however, to coat the outside of the vessel with some form of bitumen or tar composition.

With reference to the question of skin friction—if a steel ship were coated with bitumen and then an anti-fouling composition, the skin of the ship would be equally smooth, or equally rough, it would always have edges of plates and heads of rivets to the bad; whereas if a concrete ship were coated with the same composition it would always have a smoother skin, and therefore less resistance. In the case which had been instanced of a bare concrete ship and a bare steel ship there would be very little to choose.

Replying to Mr. Morris, the author said that his firm plumped for granite concrete, the hardest and very best they could get. There had been some talk in America of a light-weight concrete, something in the nature of pumice stone; in fact the Americans had advocated burnt ballast such as was seen on the sides of the clay cuttings of railways. That did not seem to him good enough to put in the form of concrete, with a thickness of two or three inches, for the skin of a ship, and he preferred something stronger as a crushing strain. He doubted its safety, and would not like to employ it. It would be an immense advantage if they could get a light concrete which was not porous. After due consideration they decided to use the very best concrete they could get, making it of granite or flint crushed to a small size.

As far as he understood, a rigid ship was a desirable form. If a ship bent very much in a sea way, that bend caused resistance to the passage through the water; whereas if she were a stiff ship she would go at a higher speed. In the *Armistice* there had been marked absence of vibration from the engine or blows from the sea, and he was of opinion that the rigidity of the concrete ship was an advantage.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Brick Substitutes.—Housing questions continue to be asked in Parliament. Regarding brick substitutes, Lieut.-Colonel Malone asked the President of the Local Government Board whether, in view of the present scarcity of bricks, the use of reinforced concrete or other substitutes for building purposes has been considered ; and, if so, what steps are being taken to ensure sufficient supplies of this material to enable building to be resumed forthwith ?

Dr. Addison : Steps have been taken to stimulate the production of large quantities of bricks, and the question of using reinforced concrete or other substitutes is also receiving consideration. It is not anticipated that there will be any shortage of cement, and the Ministry of Munitions are taking measures to ensure an adequate supply.

Hints on Town Planning.—The first of a series of lectures on various instructive subjects arranged by the Vicar of Dereham (the Rev. W. H. Macnaughton-Jones) took place at Dereham Corn Hall on March 13th, when Mr. Arthur E. Collins, the City Engineer, Norwich, explained the housing question, illustrating his lecture with an interesting variety of explanatory lantern slides. The Vicar presided, and there was a good attendance.

Having outlined the principle of housing and town planning, Mr. Collins said the difficulty of building houses at the present time was with respect to obtaining building materials. They were now moulding concrete blocks for walling purposes, and if it was done in a proper manner they could build better houses than with bricks, although he did not think that these blocks were better than Norfolk bricks. Timber was going to be very expensive, and his idea was that they could also utilise concrete for many structural parts of houses that were now made of wood, which would make a material saving in the cost. In the rooms where there was much work to be done he did not think they could beat concrete for the floors, but for the living room he would suggest now that wood was so dear a composition made of sawdust and various other things for the floor which was easy to wash. There should be a large living-room, small parlour, a kitchen and scullery, also pantry and outhouse ; but in the smaller houses the kitchen and scullery might be combined owing to the cost. The number of bedrooms would depend upon the size of the house. The modern scheme for houses was a long frontage and narrow depth, with plenty of air space and light. Instead of the old system of all houses being built alike, they should study variety. There was nothing to beat the ordinary pantile for the roofs.

Pithead Built of Reinforced Concrete.—The Fife Coal Company has recently erected a reinforced concrete pithead. The venture is only in the nature of an experiment, but the success will no doubt lead to a development of such work in the future.

Reinforced Concrete Roads.—The surveyor to the Tredegar Urban District Council, Mr. W. L. Roach, has submitted a scheme for laying Commercial Street, one of the main streets in the town, and on which there is very heavy traffic, in reinforced concrete, the cost of which he estimated would be £2,500. If the scheme is carried out it would be the first reinforced concrete road in Monmouthshire. In the surveyor's opinion this was a method of construction which had come to stay. It was decided to place the cost in the next estimate.

New Concrete Wall.—The Sidmouth Urban Council recently discussed the best way of protecting the western end of their sea wall from future ravages of the sea, considerable damage having been done recently by the heavy seas undermining the foundation of the wall in places, and threatening the collapse of the Esplanade at the western end.

The scheme includes the provision of a lower wall in front of the present wall between the groyne and the cricket field steps, the wall to be 7 ft. wide at the base and the top 6 ft. to be 5 ft. wide, the tip of the wall to be 6 ft. below the Esplanade at the cricket field steps, and level throughout the wall for a width of 3 ft. on the seaward face, to be carried down into the rock to a depth of 3 ft. The wall to be built of six to one concrete, faced with limestone, with a four to one mass concrete coping laid *in situ* in blocks 7 ft. long and 2 ft. 6 in. thick.

Reinforced Concrete Wharf at Cork.—With a view to improving the harbour accommodation the Cork Harbour Commissioners have put plans forward for a new reinforced concrete wharf 500 ft. long, and also a new graving dock.

Hydraulic Mains of Reinforced Concrete.—A short communication to the Société Technique du Gaz, by M. Martineau, describes the successful result which followed the emergency measure of constructing ten hydraulic mains in reinforced concrete, undertaken as the only possible course during the war, in consequence of the high price of cast iron and the delay in getting such work completed. The metallic reinforcement consists of a network of $\frac{1}{4}$ in. round iron wire formed in squares 4 in. by 4 in. The concrete walls have a thickness of $2\frac{3}{8}$ in. The walls of the main rest on **I**-iron running the length of the retort-bench. The valve of the tar-outlet is let into the cement. A rebate along the upper part of the main receives the cover, formed of a slab of cement into which are set the inspection and cleaning boxes. Before being taken into use, all the interior surface of the main, as also the lower side of the cover, were given three coats of hot tar. This was done in order to close up the capillary passages in the cement, and thus prevent any action of ammonia upon the metallic reinforcement—the continuous flow of tar during the working maintaining this protective coating. The main was taken into use without any mishap in the way of expansion or leakage. Test pieces of cement placed in it at the time of commencing operations, and examined six months afterwards, showed no sign of any action on the cement by the ammoniacal liquor.

Cement Workers' Wage Advances and 48-Hour Week Awarded.—The award of the Court of Arbitration on the application of the workers in the cement trade for an increase in wages and revision of working conditions is that the men and women concerned, aged 18 years and over, shall receive an advance of 5s. a week, subject to a maximum of 30s. a week over pre-war rates in the case of men, and 20s. a week over the pre-war rates in the case of women, and calculated on a basis of six working days or six shifts. The youths and girls concerned under the age of 18 years shall receive an advance of 2s. 6d. per week, subject to a maximum of 10s. a week similarly calculated.

In the case of pieceworkers, premium bonus workers, and other men working on systems of payments by results, the amounts are to be paid at the rate of 5s. and 2s. 6d. respectively per full ordinary week, over and above the week's earnings of the workpeople concerned, calculated on the present basis. Youths and girls doing adults' full work shall be paid adults' rates.

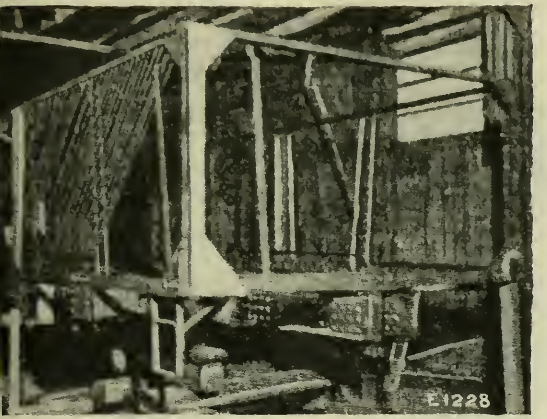
The claim that youths on attaining the age of 18 years shall receive adults' rates has not been established; but they shall on attaining the age of 18 years receive the full war wage advance payable to men. Girls on attaining the age of 18 shall receive the rates of pay and full war advances for women.

The award further provides for a reduction of the working week to 48 hours, the workers to receive such total sum as was payable for 54 hours. Overtime rates are also revised in accordance with the new rates, and the workers are to receive a week's holiday, with full pay, each year. It is also provided that the award shall not operate to depress the earnings of any of the workpeople.

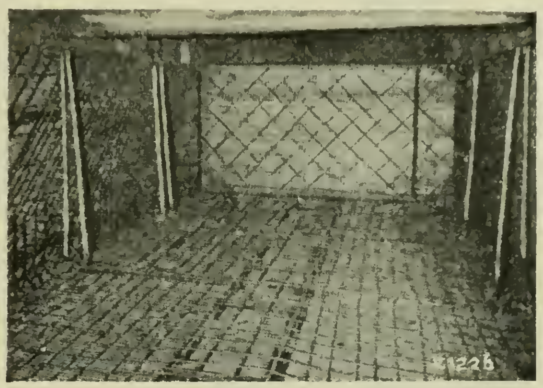
Concrete Railway Wagon.—In a recent number we made a reference to a reinforced concrete railway wagon which had been put into use at Illinois. We are now able to give some additional particulars and a number of illustrations, showing the car in course of construction. For our illustrations we are indebted to the *Engineering News Record*.

The wagon is of the gondola type, 100,000 lb. capacity, with 10 per cent. overload. It consists of a steel frame set upon a steel underframe. The concrete in the walls is 1¾ in. thick and in the floor 2½ in. thick, the floor resting upon concrete cross beams. In this work a new light weight aggregate was used, known in America as "Haydite." The weight of this car is 53,600 lb., the excess being due to the fact that the car was constructed during war time and under very unfavourable conditions. This resulted in the use of rolled steel sections which were extra heavy and also in excessive reinforcing, both of which were caused by not being able to obtain the proper steel. Under favourable conditions there is no reason why the weight could not be reduced to between 46,000 and 48,000 lb.

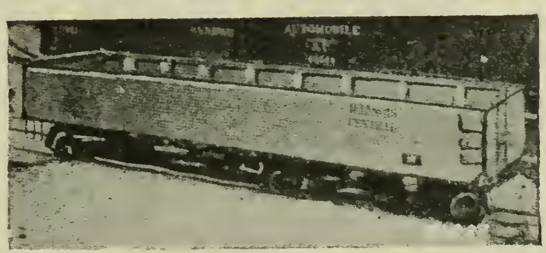
The car has a body 41 ft. long, 9 ft. 8 in. wide, and 4 ft. 8 in. deep.



el Frame and Reinforcement of Concrete Freight Car.



Reinforcement for Concrete Floor, Sides and Ends of Car.



Concrete Freight Car completed.

New Dutch Regulations for Reinforced Concrete.—The Royal Institute of Dutch Engineers has recently published a revised set of regulations replacing those issued in 1912. The most important features of the new regulations are not appreciably different from those in other countries and may be regarded as reasonable.

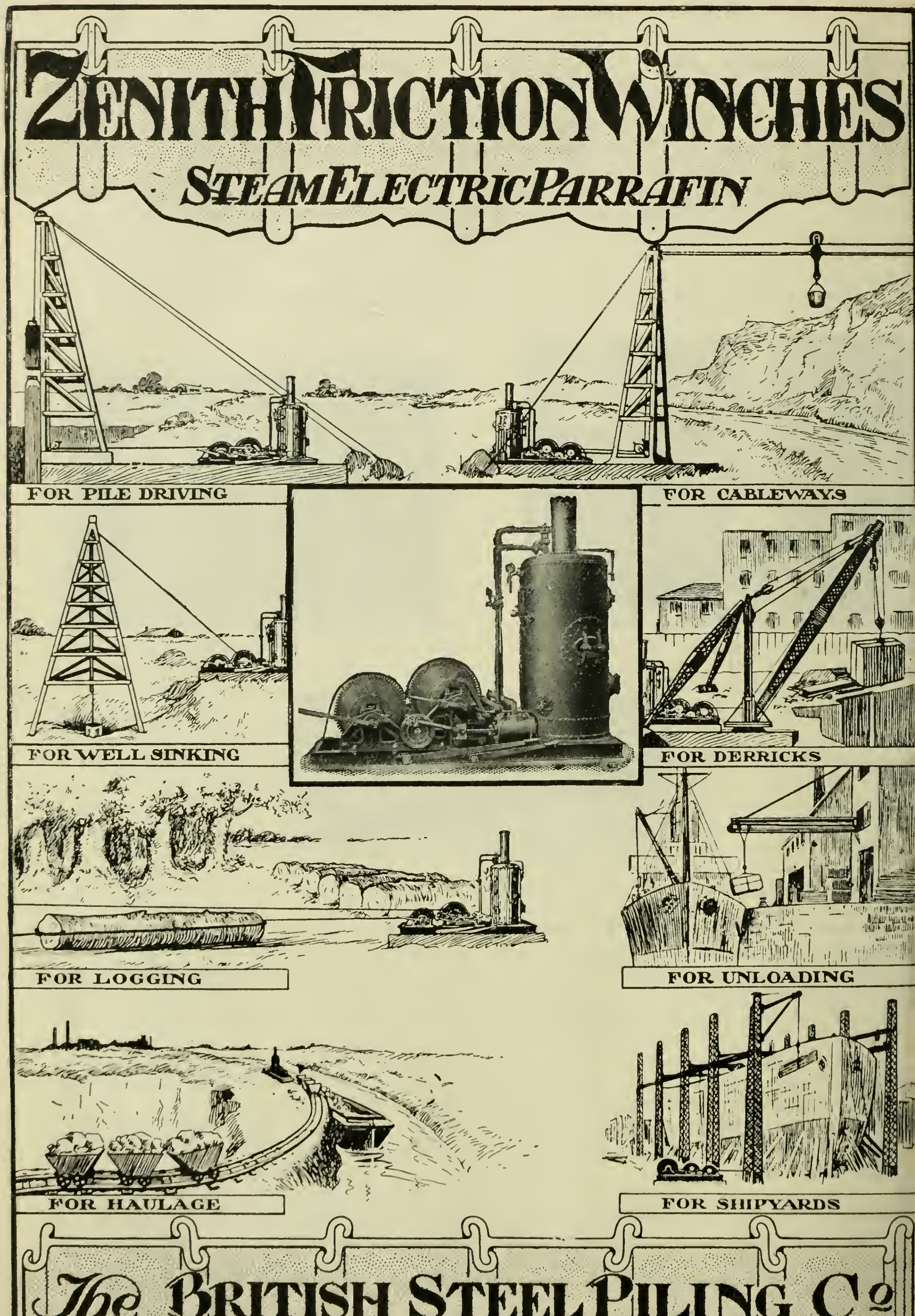
Prior to this revision the Dutch regulations were scarcely strict enough to ensure safety, but this defect has now been remedied.

The most satisfactory feature is that the proportion of sand to aggregate must be within the limits 1 : 1 and 1 : 1·5 unless at least 2 volumes of cement are used for each 3 volumes of sand, when the ratio may be increased to 1 : 2.

A Reinforced Concrete Bridge at Burgos.—A one-arch bridge of reinforced concrete has just been completed and put into use at Estepar (Burgos). The arch has a span of 32 m.

The bridge was designed by Mr. D. Pascual Aragonés, road engineer, and was erected in less than four months by the Sociedad Constructora, Bilbaina.

A Smoke-Preventing Chimney.—The devices which have been suggested for preventing down-draughts in chimneys, with the resultant discharge of smoke into the rooms, are too numerous to mention. The chimney pot shown in the accompanying



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illustrations (Figs. 1 & 2) has one claim to novelty inasmuch as it is made of concrete. As in all chimney pots of this kind, the interior is shaped in such a manner that a horizontal current of air or wind blowing on the chimney will induce an upward draught within the chimney flue; at the same time any wind tending to blow down the chimney will be prevented from entering it by the cap on the top. The chimney pot is made of plain concrete with walls of an average thickness of ¾ in. There should be a good opening in this country for concrete chimney pots of this type, but preferably of simpler internal construction, and as their manufacture is not difficult we commend it to the consideration of our readers.

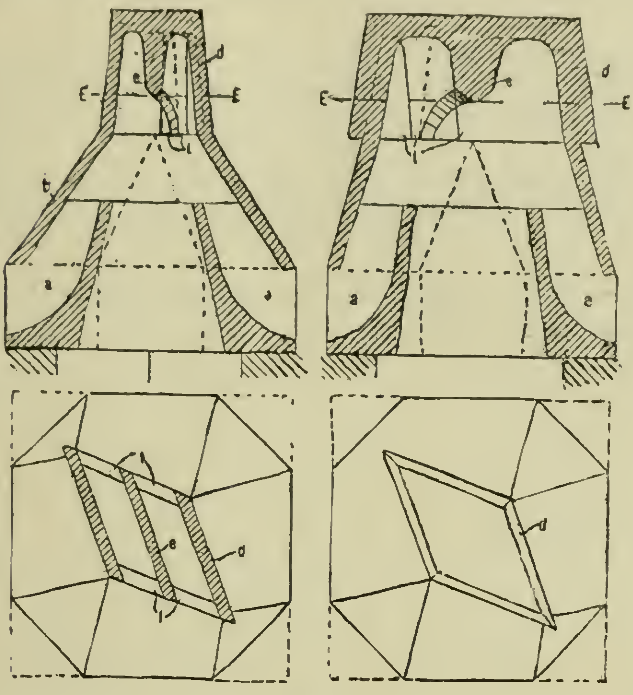


Fig. 1.

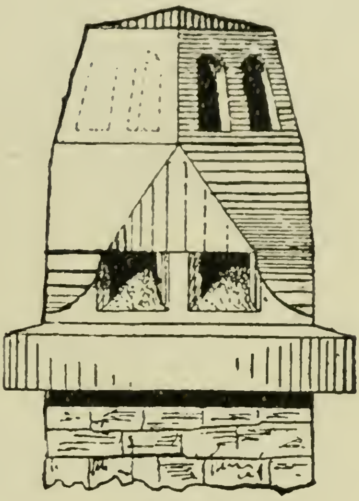


Fig 2

Army Supply Stores at Brooklyn, U.S. A.—The army supply base at Brooklyn is the largest of a number of storage and shipping plants on the seaboard for accumulating and providing supplies to the American Expeditionary Force in France. It comprises two armoured concrete warehouses, three covered piers for steamers, and one open pier for lighters, with power plant, offices, railway yards, and storage spaces. Berths are provided for twenty ocean steamers, which can be loaded either from railway wagons or from the warehouses. Small storage battery locomotives or tractors haul trains of trucks for transferring materials in and around the plant. One warehouse is 980 ft. by 200 ft., and the other 980 ft. by 306 ft., with an interior court 700 ft. by 66 ft. Both are eight stories high, with floor loads of 300 and 250 lb., and having columns spaced 20 ft. by 20 ft. Fire sprinkler and steam heater plants are installed. The three covered piers are 1,300 ft. long and 150 ft. wide, with concrete, deck for 500 lb. load and an upper storey for 300 lb. floor load. The open pier is 1,300 ft. by 60 ft. All have timber piles carrying the concrete deck. The two storey pier sheds are of steel frame construction, and bridges connect the second floors with the third floors of the warehouses. This arrangement provides two entirely separate levels for transporting material and supplies. Numerous elevators or lifts are provided. Construction was commenced May 15th, and was completed on September 26th, 1918.

British Scientific Products Exhibition.—In connection with this Exhibition, to be held in July, there will, this year, also be an Engineering Section, and it is hoped that engineers having new inventions or developments of interest to place before the public will utilise the Exhibition for this purpose. Particulars as to space available can be obtained from Mr. F S. Spiers, Organising Secretary, 82, Victoria Street, S.W 1.

Canadian Mission in London.—It may be of interest to our readers to have some information as to the constitution and activities of the Canadian Mission, which has recently been established in London at 1, Regent Street, S.W.1, by the Dominion Government.

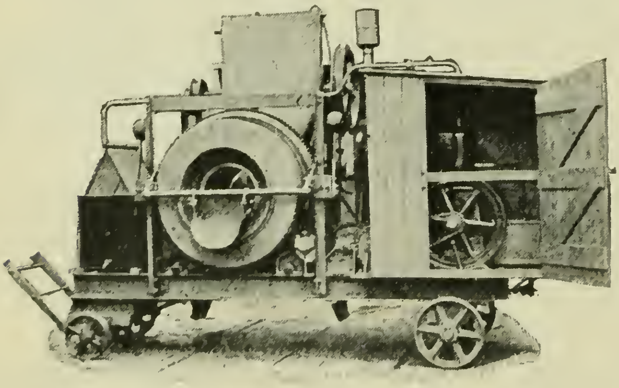
The objects of the Mission are briefly :—

(*a*) The serious tonnage position arising out of the war coupled with the numerous restrictions put in force, both in the United Kingdom and in Canada, on import and export trade, tended to sever numerous old connections which had existed for generations between the Mother Country and the Dominion. It is one of the duties of the Mission to study the question at first-hand and to devise the means of re-establishing the traditional trade.

(*b*) A great work of reconstruction and reorganisation must be undertaken in Europe during the next few years in order to repair the devastating effects of the war. Raw materials, etc., will be necessary for this work, and many articles required can be obtained from Canada.

(*c*) The Mission is convinced that the resettlement of Europe is largely dependent on sufficient supplies of food being available and distribution being properly organised. The food can only be obtained in two ways :—(1) By imports ; and (2) by increased production in Europe itself.

Canada seeks above all things to develop a larger interchange of trade with the Mother Country and indeed with all parts of the Empire.



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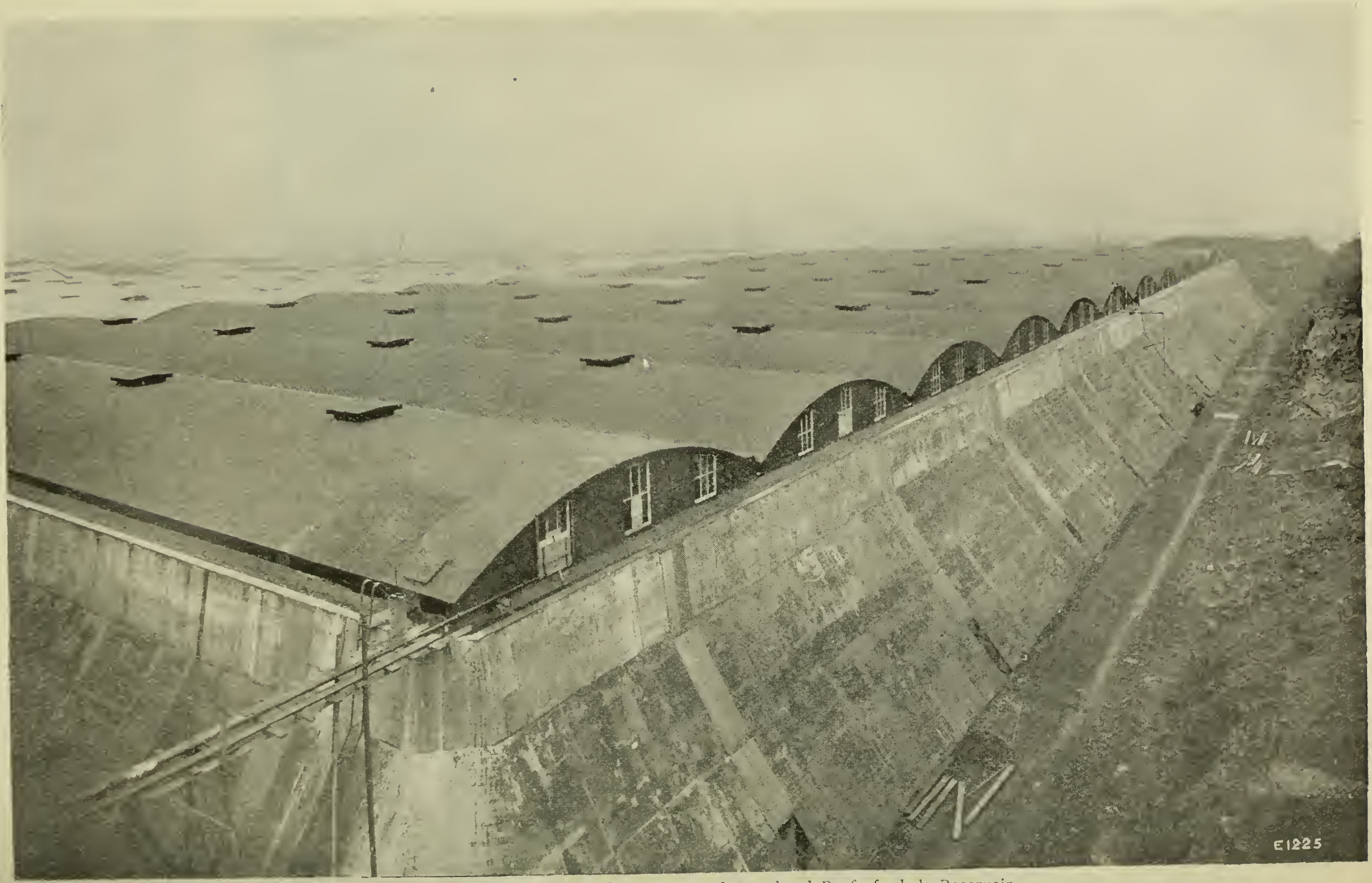


View showing Eastern Wall of Section 1 and completed Roof of whole Reservoir.

Reinforced Concrete Oil Fuel Reservoir, Rosyth.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 6. LONDON, JUNE, 1919.

EDITORIAL NOTES.

THE HOUSING PROBLEM.

ALTHOUGH we have made frequent reference to this question lately, we make no apology for returning to it in these pages, as it is one of the most urgent problems facing us at the present time.

Innumerable schemes have been prepared for the erection of houses and cottages in different parts of the country, but of the actual execution of them we have, so far, heard very little.

Many reasons are put forward against making a real start in this direction. Principal among them are the difficulties urged in regard to labour and the shortage of materials.

In regard to the latter difficulty—the shortage of bricks is one of the primary causes put forward. We understand that there is an immediate need for 500,000 houses, of which 200,000 are required in the Greater London area, and the remainder in different parts of the country. Necessarily large quantities of materials of all kinds must be forthcoming for this work. Granted, however, the urgent need for a large quantity of bricks, and assuming that these will be used for a number of building schemes, are we absolutely limited to bricks only? Is it not time we overcame our conservatism and we turned our attention to other and more modern materials, which would form excellent substitutes, and help to tide over the present shortage?

Regarding these substitutes, we would again draw attention to the use of concrete for building a large number of the cottages we require. We have in these pages repeatedly given examples of its application to this purpose. During the war period it has been used in the form of blocks and slabs for a large number of small structures and for several housing schemes, and in connection with these housing schemes we desire again to call attention to the Chepstow cottages, which are an excellent example of the use of concrete for cottages.

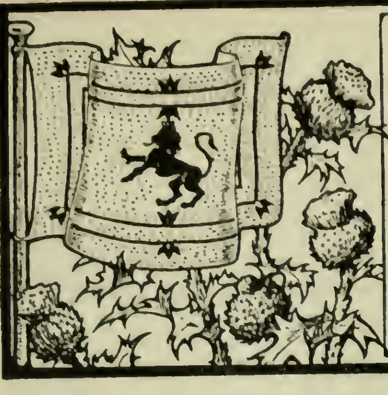
We have facilities for producing large quantities of Portland cement in the country, and the aggregates needed for making concrete are in most cases to be found locally, leaving only the cost of transportation of the cement, which should not be excessively high if proper facilities are provided by the Government. Thus the material for the building of a large number of houses and cottages is almost immediately available. Moreover, although we do not pretend that concrete entirely solves the difficulty as regards building, it will, to a certain extent, overcome the present shortage of timber, for it can advantageously be used for sills, lintels, flooring, fencing, roofing tiles, etc.

A strong objection often urged against the use of the material is its cold and unpleasing appearance, but experience has shown, and is showing increasingly, that this objection can be met and overcome.

Then there is the difficulty of the local building by-laws, as ruling at present in many districts, which would make the use of concrete prohibitive. But on this score we now have the assurance of Dr. Addison, on behalf of the Local Government Board, who, at the opening of the Model Homes Exhibition (inaugurated by the *Daily Express* and the *Sunday Express*), at the Central Hall, said " that there would be no ' stickiness ' on the part of the Local Government Board in this direction. Old by-laws would have to go ; they would be scrapped wholesale in all cases where schemes had been approved by the Board."

Equally significant is an article which appeared in a recent issue of the *Local Government Chronicle* on the subject of concrete in relation to the housing problem, in which the writer frankly advocates the use of this material. We conclude our notes by giving one or two short extracts from this article, as it should be of particular interest, when we bear in mind the earlier attitude taken up by the Board on this subject :

> " A great deal of nonsense is being written about concrete houses by those who evidently know little or nothing about modern methods of construction, and a good deal of misrepresentation both by those who cannot rid themselves of old prejudices and those who have axes to grind in some other system. Let it be frankly admitted that some prejudices are well grounded. Solid concrete walls, which are now being advocated in certain quarters for housing schemes, have done untold harm to a building material which, though in many respects superior to any other, ought never to be employed in this manner. Condensation begins at once, with the inevitable result that houses built with solid concrete walls are cold in winter and can become unbearably hot in summer. They are liable to crack, as well as to ' sweat ' on the inside. In short, they fully justify most of the criticisms levelled at them.
>
> " The fault in such cases, however, lies not in concrete itself, but in its misuse, in just the same way that equally miserable houses are built of brick—or any other material for that matter. Could anything be worse than the mean streets of decayed homes which John Burns has neatly described as square brick boxes with lids on top ? A good brick is an excellent thing, but it takes time to mature, and is very different in quality to-day from that which was produced, say, thirty years ago. If the much talked of 300,000 houses which have to be built during the coming year—needing, according to the official estimate in the report of the committee appointed by the Ministry of Reconstruction, 6,000,000,000 bricks—it must follow that only the poorest material will be available in countless cases. It is time, therefore, to rid ourselves of many preconceived ideas, and examine without prejudice the newer forms of construction with concrete blocks and slabs, which overcome all the objections on the score of dampness and discomfort, as well as the equally familiar one of unsightliness."



A REINFORCED CONCRETE OIL FUEL RESERVOIR AT ROSYTH.

For the following particulars and illustrations we are indebted to the courtesy of the Department of the Civil Engineer-in-Chief of the Admiralty.—ED.

THE construction of a large reservoir at Rosyth for the storage of oil fuel for the use of H.M. ships in the Firth of Forth has recently been completed by the Admiralty. The reservoir is built of concrete on a rock foundation, the site being the bed of the sandstone quarry, known as Howe Cove, from which stone was quarried for the purpose of building the new dockyard. The use of concrete as a material of construction for oil reservoirs of large size is a novelty, and the design of the structure, as well as the methods adopted in construction, present some features of interest.

Walls.—The walls are built in the form of retaining walls, with an average height of 35 ft., and are reinforced with steel rods laid in the direction of the length of the wall in layers 3 ft. apart in a vertical direction and spaced from 1 ft. to 4 ft. apart in a horizontal direction.

The wall is divided into sections ranging in length from 54 ft. to 58 ft. Between each of these sections is a gap 3 ft. wide ; this gap is closed by means of a continuous steel plate running from top to bottom of the wall, with the two ends bent in a " Z " shape and embedded in the concrete of adjoining sections of the wall, thus forming an expansion joint between the two sections. The 3 ft. space between the sections and around the plate is filled with fine concrete, but only to a thickness of 6 ft. from the face, thus giving support to the plate but at the same time localising any expansion or contraction in the concrete of the walls to the points at which the expansion joints are situated.

Subdivision.—The reservoir is divided into two halves (sections 1 and 2) by means of a main division wall carried to the same height as the external walls, reinforced in the same manner and designed to withstand the full head of oil pressure on either side. Each section is again subdivided into two by means of a dwarf wall having an average height above the floor of the reservoir of 16 ft.

Floor.—The concrete floor has a minimum thickness of 2 ft. 9 in., and is laid to falls for the purpose of draining and brushing the sludge to the pumps whenever it is necessary to clean the reservoir.

Oil Mains.—The oil is pumped in or out of the reservoir by means of cast-iron oil mains. There are four branch pipes to these mains passing through the exterior walls at or about floor level, one branch for each subdivision of the reservoir. Each branch bears at its internal extremity a pair of swing arms.

These consist of two steel pipes connected to the branch pipes by means of swivel joints on trunnions, allowing a movement of the swing arms in a vertical direction and so admitting of the oil being introduced or drawn off at any desired level.

Recovery of Oil.—To provide for the collection and recovery of any oil that might possibly find its way through the expansion joints, the precaution was taken of installing drainage sumps on the outside of the external walls. These are conveniently situated in the recesses between the sections of the wall above referred to, and are fitted with valves and branch pipes leading to a secondary system of oil drainage pipes encircling the reservoir.

Roof.—The roofing system adopted is that known as the " Belfast " lattice timber truss. The trusses are 50 ft. in span with a horizontal lower boom, the upper boom being an arc of a circle of 50 ft. radius.

The trusses are spaced about 10 ft. apart. Their ends, where not bearing on the edges of the wall, are carried on a system of horizontal timbers supported either directly or by means of inclined struts on the main vertical roof posts. These roof posts, which are of timber, are carried in their turn by dwarf concrete pillars, built up from the ground level, one concrete pillar and roof post serving for every three trusses.

The roof purlins are laid on the upper booms of the trusses and carry tongued and grooved roof boarding, covered with " Rok " patent roofing felt, which is tarred and " harled " with fine whinstone chippings. Lighting is provided by means of glazed frames fixed in the gable ends, and access to the interior is obtained through manholes in the roof.

Ventilation is provided by means of large square holes in the roof with overlapping covers.

The valleys, formed between the arched spans of the roof, which are also fitted with snowboards, serve to lead the rain water falling on the roof into gutters formed in the concrete at the summits of the exterior walls and the main division wall. From these gutters the rain water is carried off through a system of down pipes, fixed to the exterior of the walls.

Roadways, Drains, &c.—The whole reservoir is surrounded by a macadam roadway, the oil mains, oil drains, land drains and drains to carry off rain water falling on the roof being buried in the ground alongside this roadway.

Construction.—To obtain the required level area for building the reservoir a considerable amount of rock excavation was necessary in addition to that which had previously been removed in quarrying stone for the construction of the dockyard. All loose rock was also removed from the floor area. In many cases this involved excavation below the level necessitated by the floor itself. The spaces so formed were filled with concrete up to the underside of the floor.

The necessity for observing every precaution to ensure the reservoir being oiltight regulated the order in which the various operations of construction were to be carried out, and it was decided that—

(1) To reduce temperature variations to a minimum, the roof should be constructed before the floor was laid.

(2) To prevent any cracks appearing in the concrete of the walls due to

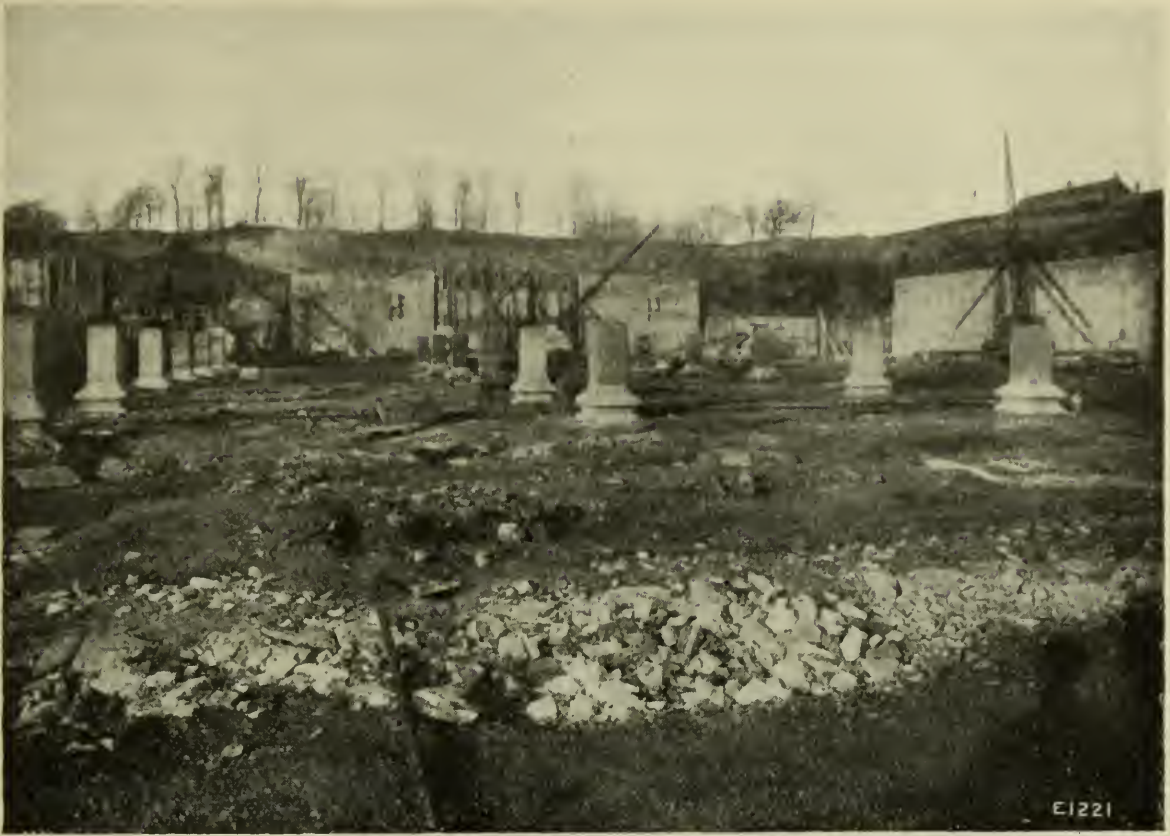


FIG. 1. View of Northern portion of Section 1 in Course of Construction.
REINFORCED CONCRETE OIL FUEL RESERVOIR, ROSYTH.

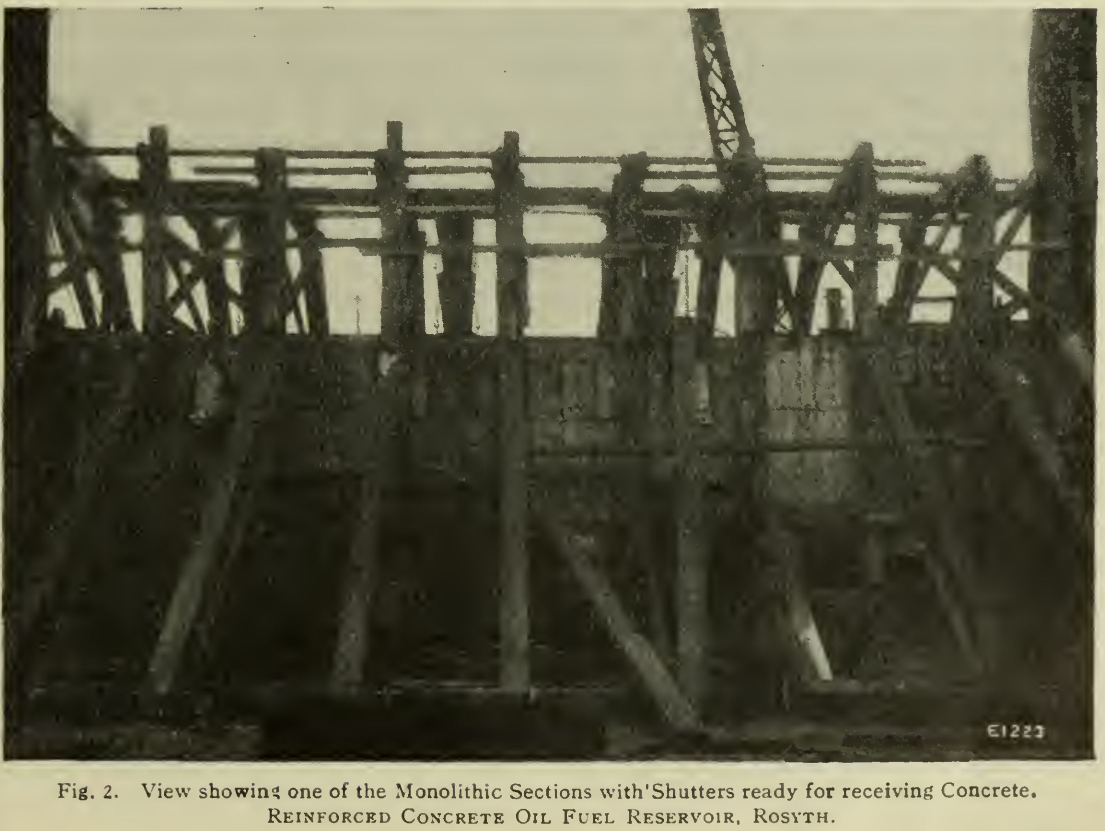


Fig. 2. View showing one of the Monolithic Sections with'Shutters ready for receiving Concrete.
REINFORCED CONCRETE OIL FUEL RESERVOIR, ROSYTH.

contraction during setting or due to changes of temperature, the walls should be built in independent monolithic sections.

(3) Alternate sections should first be built, each section having incorporated in it the bent edges of the two expansion plates, one at either end of the section.

(4) The intermediate sections should then be built incorporating the other bent edges of these plates, leaving, except for the plates, a clear space between adjoining sections.

(5) That these spaces should be filled in during the winter months—*i.e.*, during the period of maximum contraction of the monolithic sections.

The stone used for concrete was whinstone, of a sound, hard quality, obtained from the Admiralty quarry at Castlandhill and quarried by the contractor for this work. The stone was carried from the quarry on the contractor's own railways and was crushed, screened and elevated into storage bins at a combined crushing battery and gauging station erected near the site of the reservoir.

The sand was clean pit sand conveyed by rail from the contractor's sand workings at Pettycur, near Burntisland, and unloaded into storage bins at the gauging station.

The cement was British Standard Portland cement, transported by sea, unloaded at the contractor's jetty, and stored in sheds, from which it was conveyed by belts, as required, to the bins at the gauging station.

The "mass" concrete was composed of stone, sand, and cement in proportions 7 : 3 : 1, the stone being broken to pass a 2-in. ring. The fine concrete for facing was composed of stone, sand, and cement in proportions 3 : 1½ : 1, the stone being broken to pass a ½-in. ring.

The constituents were drawn and gauged mechanically from the bins at the gauging station, run to the site on flat trucks in steel boxes holding 2 cu. yd. each, and mixed alongside the work in "Smith" rotary mixers of 2 cu. yd. capacity. From the mixer the concrete was spouted into specially constructed boxes and lifted into position by means of steam derrick cranes with long jibs. This special type of box or "pouring skip" is made of sheet steel. The upper part is square and the lower part is tapered and terminates in an orifice controlled by a sliding door for regulating the flow.

The walls were constructed of "mass" concrete, with a facing of fine concrete and reinforcement as already described. The "fine" concrete was deposited at the same time as the mass concrete, the two being kept separate during deposition by means of steel plates, which were, however, drawn immediately after the deposition of the concrete to ensure intimate coherence of the two different qualities. This "fine" concrete facing was also carried around the gutter on the top of the wall and around a recess left at the base of the wall for forming a joint with the floor.

The arrangement of shuttering is clearly shown in the illustrations. The timberwork was exceptionally heavy to withstand the pressure due to the height of concrete deposited in one operation.

The pillars to carry the roof supports were constructed at the same time as the walls and of the same quality of concrete, except for the bottom portions of each pillar, which were made of "fine" concrete and recessed in the same manner as the walls for forming a junction with the floor.

The roof trusses have already been described. They were built complete on a prepared platform alongside the reservoir, lifted over the wall by means of a derrick crane and placed in position on the supports by a travelling steam crane working inside the reservoir. By leaving out portions of the wall temporarily it was possible to obtain easier access for the materials for the construction of a portion of the roof and also the floor. After the outside walls were built, the material for the remainder was lifted over the walls by derrick cranes.

The floor was constructed of mass concrete of a minimum thickness of 2 ft. with a surfacing of "fine" concrete. It was laid in long strips, the fine concrete following immediately on the top of the mass concrete. The junction between one strip and the next was made with a scarfed joint, the "fine" concrete being carried round this joint and also around all junctions of floor with walls and pillars.

Testing.—On the completion of section 1 water was introduced to test the reservoir for tightness, but observations of the level of the water showed that it was escaping; an increase in the flow of water in the sub-floor drains indicated that this leakage was taking place through the floor. The water was, therefore, run out, and on careful examination being made of the floor it was found that, in spite of every precaution having been taken during its construction, the joints between one strip of flooring and the next adjacent had opened. This may have been due to the natural contraction of the concrete in setting or to contraction induced by the cooling action of the water used for testing.

Various remedial measures were applied, but the possibility of further cracks forming at a later date with consequent loss of oil was considered sufficient justification for treatment of the entire floor in some such manner as would effectually eliminate this contingency.

Reinforced Concrete Floor.—It was therefore decided to cover the entire floor with 6 in. of concrete, having two layers of expanded metal embedded in it. "Fine" concrete, as previously described, but in the altered proportions $2\frac{1}{2} : 1\frac{1}{2} : 1$, was used, the expanded metal being $\frac{1}{4}$ in. by $\frac{3}{16}$ in. with a 3-in. mesh.

In the laying of the reinforced floor the concreting was carried out in squares. These squares and the rectangular sheets of expanded metal used for reinforcing were arranged in such a manner that under no circumstances did the edge of one sheet occur in the same vertical plane as the edge of another sheet, nor did either occur in the same vertical plane as the edge of the concrete square. Alternate squares in alternate rows of squares were concreted first, then, after allowing sufficient time for these to mature, the intermediate squares in these alternate rows were filled in, forming alternate strips across the floor and still leaving the intermediate strips (or rows of squares) empty. The squares in these intermediate strips lying between the squares first concreted were then put in, and, finally, the remaining squares. It will thus be seen that the alternate squares in each strip were given time to shrink before the other squares completing the strip were put in, and that the alternate strips were given time to shrink before the intermediate strips were put in.

A strip round the edge of the floor and at the bases of the walls was left out until all the remainder of the floor had been covered. A dove-tailed chase was cut in the base of the wall into which the expanded metal of this strip was inserted and the concreting then completed.

In order to ensure the maximum density of the concrete in the reinforced floor, it was decided to adopt some system of vibrating in place of the customary ramming. A number of practical experiments were carried out and, as a result, the method adopted was vibration by means of Flotmann pneumatic boring machines (of the type used for rock drilling) fitted with steel plates in lieu of drills and applied to the concrete when the latter was in a semi-plastic condition. The surface of the concrete was finished off by sliding the adapted machines, with extra weight added, to and fro upon planks resting on the top of the concrete, and the surface so produced was so good that only smoothing with a mason's float was necessary to give it the requisite final smooth finish. The concrete was all hand-mixed, as only by careful observation during mixing could the most suitable degree of moisture be obtained.

The method adopted for the construction of the reinforced floor is described in some detail, as it is believed to be a comparatively modern process and proved on testing to give entirely satisfactory results.

Final Testing of Section 1.—The final testing of section 1 of the reservoir was carried out by pumping salt water into it from the Firth of Forth at the rate of 4,000 gals. per minute by means of a suction dredger outfit and a temporary pipe line 24 in. in diam. and 2,400 ft. in length. Some small leaks were discovered, principally in the division wall between sections 1 and 2, due to the water entering the wall at the expansion joints, which were of a different type (necessitated by the wall being built to withstand oil pressure on either side) and did not prove to be quite as effective as those used in the exterior walls. These leaks were dealt with, without drawing off the water, by boring inclined holes downward into the concrete until the leaks were tapped, and grouting up with cement under a pressure of 100 lb. per sq. in. This effectually stopped all leakage. The water was then run off and section 1 of the reservoir put into use for the storage of fuel oil.

Times of Construction.—The concrete work in section 1 was commenced in July, 1916, and completed in August, 1917. Testing and other remedial work occupied the period until February, 1918, when the reinforced floor was put in hand. This was completed in July, 1918, but testing, grouting of leaks, emptying, cleaning out, etc., prevented the reservoir being put in use for storage of oil fuel until September, 1918.

Section 2 of the reservoir, which is similar to the section first built, was commenced in August, 1917, and is now practically complete. It is, like section 1, provided with a reinforced concrete floor.

Quantities.—The total amount of rock excavation carried out in the construction of the two sections was upwards of 300,000 cu. yd., and the concrete deposited amounted to about 98,500 cu. yd. The combined capacity of the two sections is about 60 million galls., and the area occupied by the reservoir and surrounding roadway, pipe track, etc., is 11¼ acres, the roof area being 7½ acres.

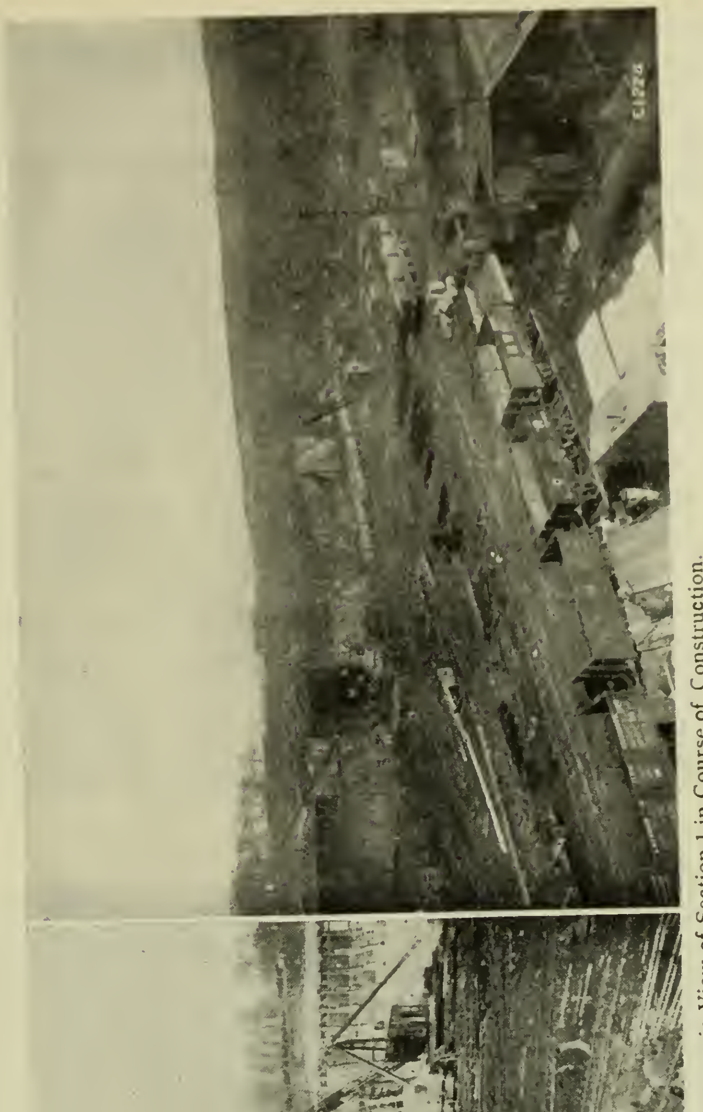


Fig. 3. A Panoramic View of Section 1 in Course of Construction.
REINFORCED CONCRETE OIL FUEL RESERVOIR, ROSYTH.

The accompanying illustrations show the work at various stages.

No. 1 is a view of the northern portion of section 1 under construction. The concrete roof pillars with the recesses at their bases for forming a joint with the floor are seen in the foreground. In the background are seen two monolithic sections of the wall completed, one partly completed (on the middle right) and one with shuttering ready for concrete (on the middle left). The expansion plates are seen built into the completed sections and in process of being built into the adjoining sections. No. 2 shows one of the monolithic sections with shutters fixed ready for receiving concrete. The expansion plates are seen already fixed in place for the whole height of the wall at each end of the section. The frontispiece shows the eastern wall of section 1 and the completed roof of the whole. The darker portion is the roof of section 1, the lighter the roof of section 2, the latter at this stage not having been tarred. This photograph also shows the recess at the expansion joints between the monolithic sections of the wall in which are situated the sumps and valves for recovery of any oil leaking past the expansion plates. No. 3, taken on March 13th, 1917, is a panoramic view of section 1 during the process of construction. Section 2 was constructed on the site shown in the foreground of this picture. No. 4 shows the roof for the northern portion of section 1 in process of erection. On the left is also seen one of the monolithic sections partly built with expansion plates standing up to the full height of the wall.

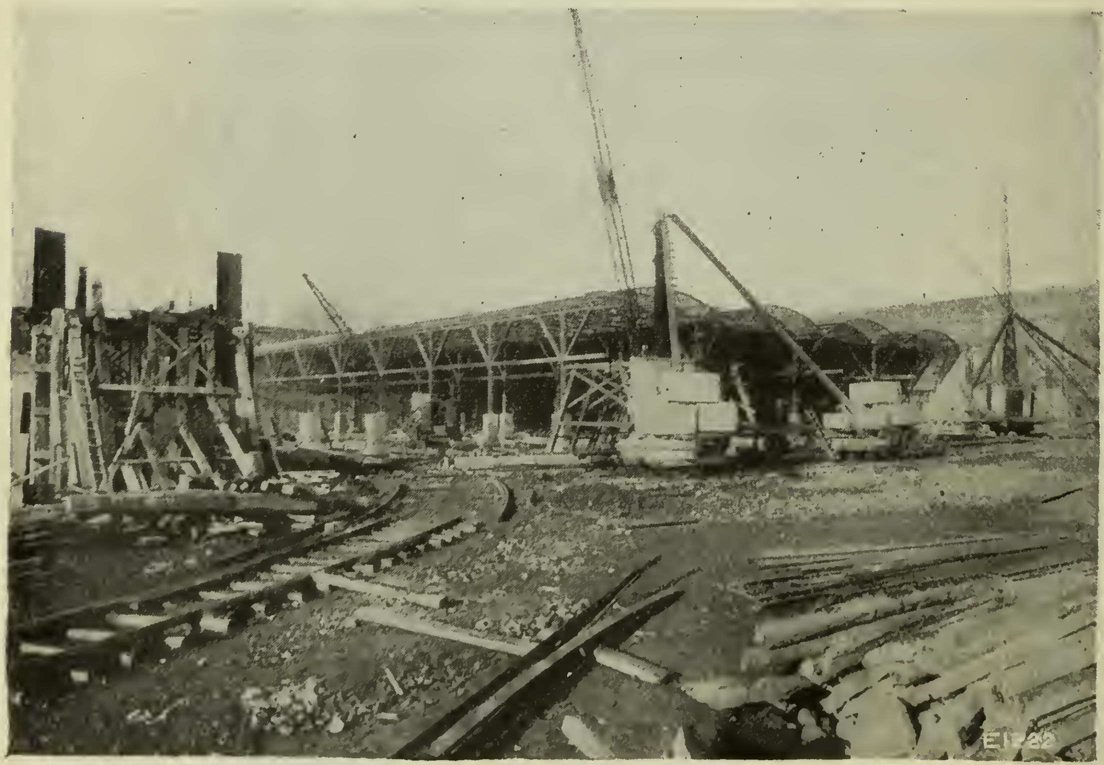


Fig. 4. Roof for Northern portion of Section 1 in Course of Erection,
REINFORCED CONCRETE OIL FUEL RESERVOIR, ROSYTH.

PROBLEMS IN THE THEORY OF CONSTRUCTION.

THE STRENGTH OF PILLARS. II.

By EWART S. ANDREWS, B.Sc.Eng., M.C.I.

For the earlier article on this subject see "Concrete and Constructional Engineering," March 1918, p. 120.—ED.

CASE I. PIN-JOINTED OR HINGED ENDS (*contd.*).

General Formula for Practical Design.—In order to obtain a formula for use in design of steel pillars in which the loading is as central as possible, *i.e.*, for the ordinary case in practice, in which such eccentricity as exists is due only to accidental crookedness, we suggest that the eccentricity e_o be taken as equal to $\frac{l^2}{20{,}000\ n}$, *i.e.*, proportional to the square of the length and inversely proportional to the least depth of the section. This corresponds to ¼ in. for a pillar 10 ft. long and 6 ins. deep.

Our formula (13) then becomes:

$$c_y = c_p\left\{1 + \frac{l^2}{20{,}000\ g\left(1 - \frac{c_p}{c_E}\right)}\right\} \qquad (16)$$

$$\begin{aligned} c_y - c_p &= \frac{l^2}{20{,}000\ g^2} \cdot \frac{c_E \cdot c_p}{(c_E - c_p)} \\ &= \frac{l^2}{20{,}000\ g^2} \cdot \frac{\pi^2 E g^2}{l^2} \cdot \frac{c_p}{(c_E - c_p)} \\ &= \frac{\pi^2 E}{20{,}000} \cdot \frac{c_p}{(c_E - c_p)} \qquad (17) \end{aligned}$$

For steel $E = 30{,}000$ kips per sq. in., so that we have:

$$(c_y - c_p)\ (c_E - c_p) = 14{\cdot}80\ c_p$$

For mild steel we have: $c_y = 45$

$\therefore$ Our formula becomes:

$$c_p^2 - (59{\cdot}80 + c_E)\ c_p + 45\ c_E = 0 \qquad (18)$$

The real solution of this quadratic equation gives:

$$c_p = \frac{(59{\cdot}80 + c_E) - \sqrt{(59{\cdot}80 + c_E)^2 - 180\ c_E}}{2}.$$

Putting as before $\frac{c_p}{45} = Q$ the pillar stress coefficient, we obtain the values plotted in *Fig.* 3; in this figure we give also the working stresses based upon a factor of safety of 3 on the yield point.

Comparison with Modified Euler Formula.—This formula is based upon the assumption that the pillar is initially straight but that the load is applied slightly out of centre by an amount e_0.

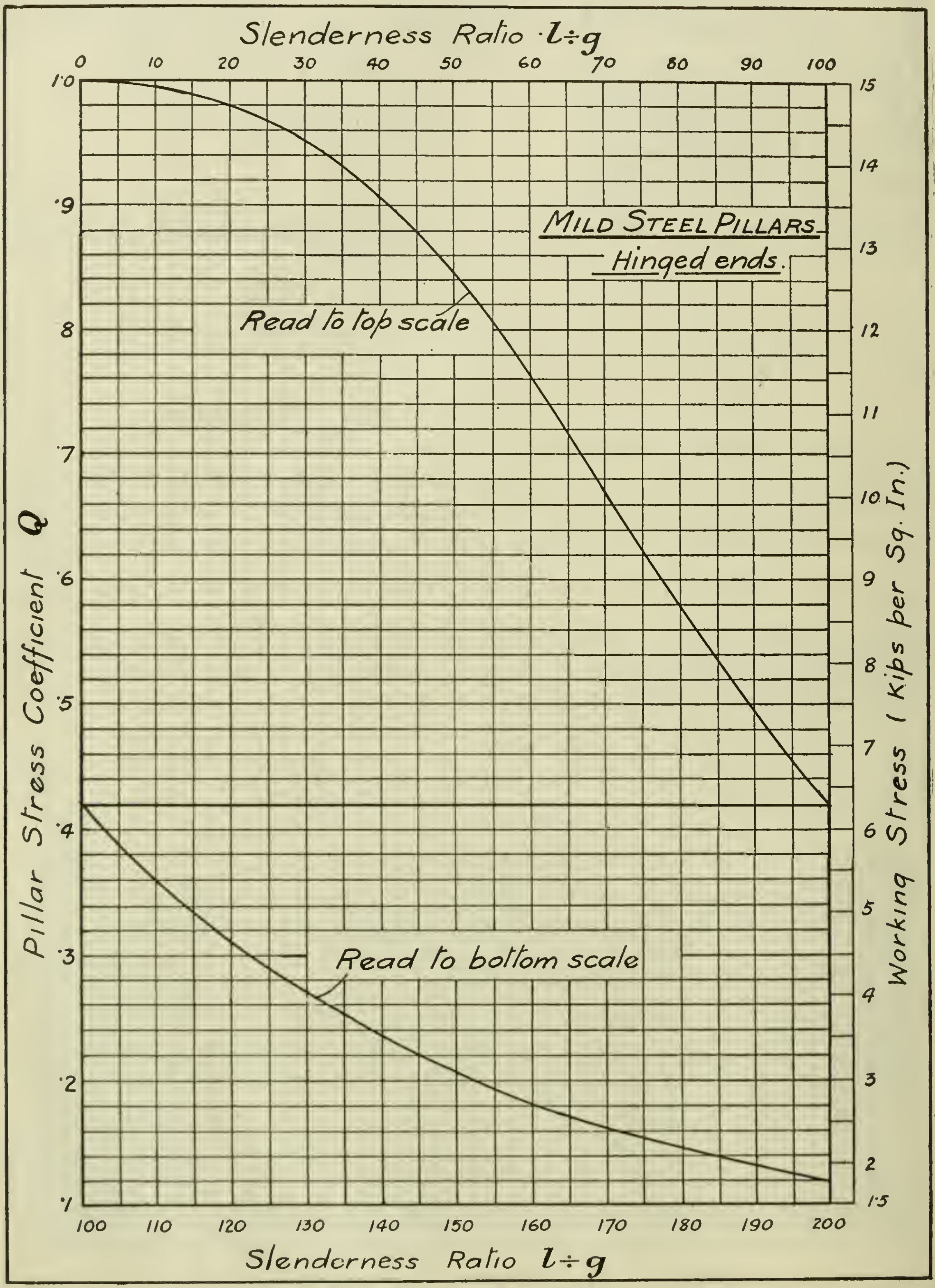


FIG. 3.

It gives the result: *

$$Q = \frac{1}{1 + \frac{e_0 u}{g^2 \cos}} \qquad (19)$$

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* For proof see the author's "Strength of Materials" (Chapman & Hall, Ltd.), p. 306

where θ is called the Eulerian angle and is given by

$$\theta = \frac{l}{2g}\sqrt{\frac{c_p}{E}} = \frac{\pi}{2}\sqrt{\frac{c_p}{c_E}}$$

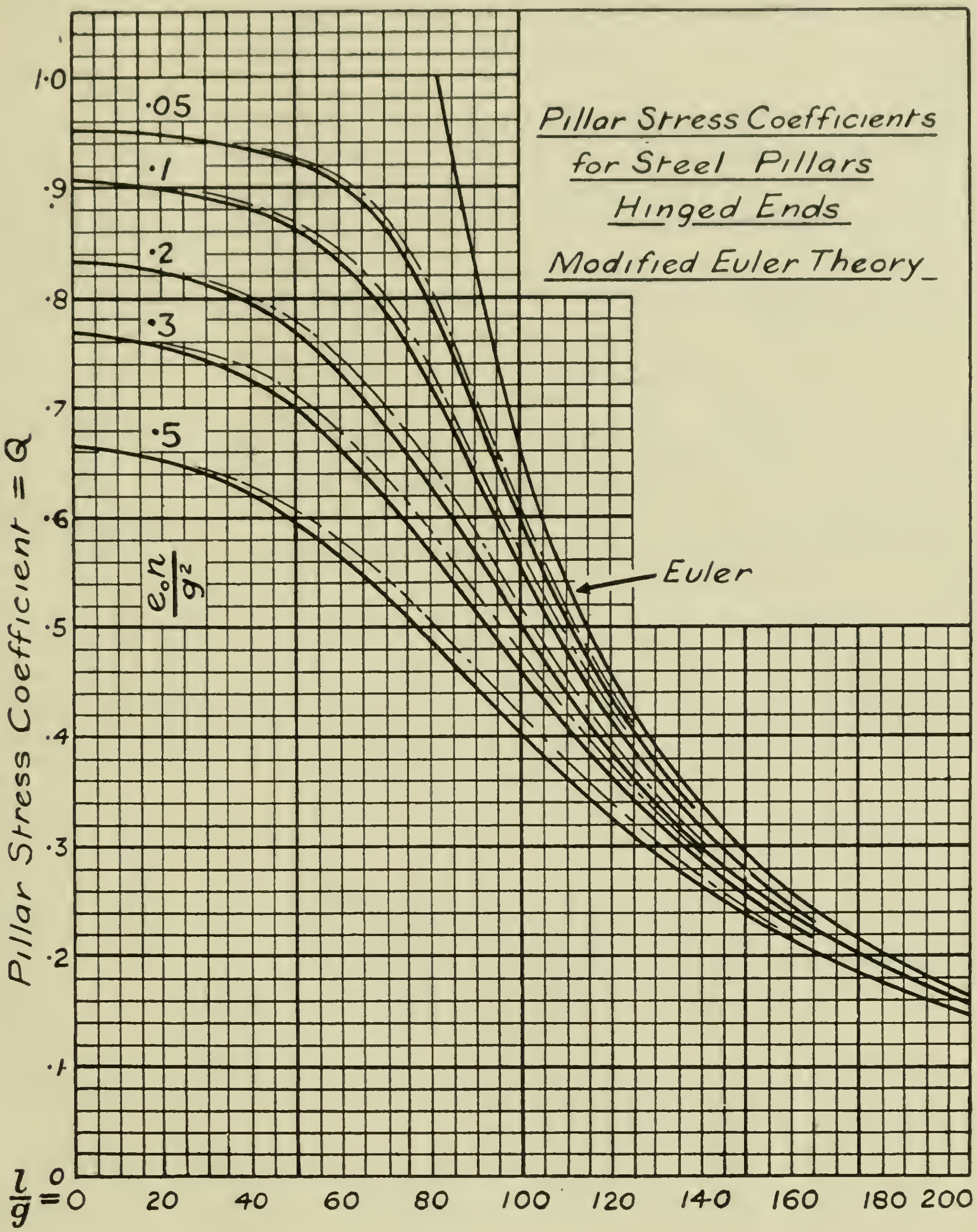

Fig. 4.

The trigonometrical functions of these Eulerian angles will occur repeatedly in our subsequent treatment of this subject and are not usually given, so we have calculated them and give them at the end of this article in tabulated form.

We have calculated the values of Q in accordance with equation (19) for the same range of values of $\frac{e_o n}{g^2}$, as we considered previously, and have expressed the results in graphical form in *Fig.* 4, alongside the values obtained from equation (15), which are indicated in dotted lines.

It is clear from this figure that the two formulæ give results which are practically the same; this will have an important bearing upon the consideration of eccentrically-loaded pillars.

CASE II. FIXED-ENDED PILLARS NOT INITIALLY STRAIGHT.—Next consider the case of a pillar initially curved as indicated in *Fig.* 5, but absolutely fixed at the ends so that under deflection there is no change in the slope of the pillars at the ends.

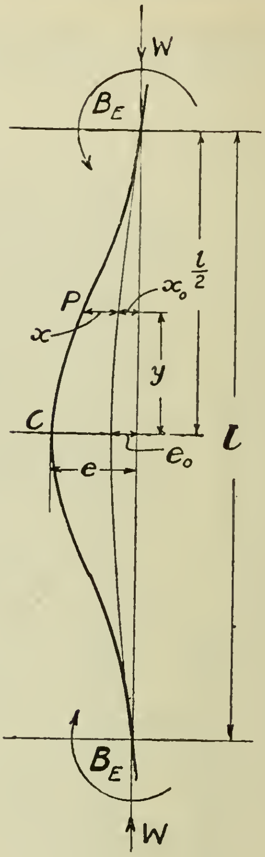

FIG. 5.

We will assume as before that the initial eccentricity at a point P is given by

$$x_o = e_o \cos\left(\frac{\pi y}{l}\right)$$

Since the pillar is bent under load to the form indicated by the heavier line, there will be reverse bending moments B_E induced at the ends.

At the point **P**, therefore, we have a bending moment B given by

$$B = W\left\{x + e_o \cos\left(\frac{\pi y}{l}\right)\right\} - B_E \qquad (20)$$

and we may also write $B = -EI\,\dfrac{d^2x}{dy^2}$

$$\therefore \frac{d^2y}{dx^2} = \frac{B_E}{EI} - \frac{W}{EI}\left\{x + e_o \cos\left(\frac{\pi y}{l}\right)\right\}$$

∴ Writing $\dfrac{W}{EI} = m^2$, we have

$$\frac{d^2y}{dx^2} = m^2\left\{\frac{B_E}{W} - x - e_o \cos\left(\frac{\pi y}{l}\right)\right\} \qquad (21)$$

The general solution of this differential equation gives

$$x = A \sin my + C \cos my + \frac{e_o m^2 l^2}{\pi^2 - m^2 l^2} \cos \frac{\pi y}{l} + \frac{B_E}{W} \qquad (22)$$

To obtain the particular solution for our problem, we note that $x = o$ for $y = \pm\frac{l}{2}$.

For this to be possible we must have

$$A = o$$

$$C = -\frac{B_E}{W \cos \frac{ml}{2}}$$

$$\therefore x = \frac{B_E}{W}\left(1 - \frac{\cos my}{\cos \frac{ml}{2}}\right) + \frac{e_o m^2 l^2}{\pi^2 - m^2 l^2} \cdot \cos \frac{\pi y}{l} \qquad (23)$$

From this we obtain by differentiation:

$$\frac{dx}{dy} = \frac{mB_E}{W} \frac{\sin my}{\cos \frac{ml}{2}} - \frac{e_o m^2 l \pi}{(\pi^2 - m^2 l^2)} \sin \frac{\pi y}{l} \qquad (24)$$

This represents the slope of the deflected form of the pillar to its original form, and we have seen already that this slope must be zero at the ends where $y = \frac{l}{2}$; putting in this value for y we have

$$\frac{mB_E}{W}\tan\frac{ml}{2} - \frac{e_o m^2 l\pi}{(\pi^2 - m^2 l^2)} = O$$

$$i.e.,\ B_E = \frac{We_o \pi ml}{(\pi^2 - m^2 l^2)} . \cot\frac{ml}{2} \qquad (25)$$

Point of Maximum Bending Moment.—The bending moment at the centre, B_c, is equal to $(We - B_E)$ and at the ends is B_E; we have next to investigate the question as to which of these will be numerically the greater in any case arising in practice.

Putting $y = o$ in equation (23) and adding e_o to obtain e we have

$$e = e_o + \frac{B_E}{W}\left(1 - \sec\frac{ml}{2}\right) + \frac{e_o m^2 l^2}{\pi^2 - m^2 l^2}.$$

$$\therefore\ B_c = We - B_E = We_o - B_E \sec\frac{ml}{2} + \frac{We_o m^2 l^2}{\pi^2 - m^2 l^2}.$$

$$= \frac{We_o \pi^2}{\pi^2 - m^2 l^2} - B_E \sec\frac{ml}{2}.$$

$$= \left(\text{by equation (25)}\right) \frac{We_o \pi^2}{\pi^2 - m^2 l^2} - \frac{We_o \pi ml}{(\pi^2 - m^2 l^2)} \operatorname{cosec}\frac{ml}{2}.$$

$$\therefore\ B_E - B_c = \frac{We_o \pi}{\pi^2 - m^2 l^2}\left\{ml \cot\frac{ml}{2} - \left(\pi - ml \operatorname{cosec}\frac{ml}{2}\right)\right\}$$

$\therefore$ B_E will be numerically greater than B_c if $\cot\theta$ is numerically greater than $\frac{\pi}{2\theta} - \operatorname{cosec}\theta$, where $\theta = \frac{ml}{2}$ as before. At one end of the range of values take $\frac{l}{g} = 40$; the value of c_p for this must be something just less than 45 kips per sq in.

$$\text{Now } \theta = \frac{ml}{2} = \frac{l}{2}\sqrt{\frac{W}{EI}} = \frac{l}{2}\sqrt{\frac{c_p A}{EAg^2}} = \frac{l}{2g}\sqrt{\frac{c_p}{E}} = (\text{as before stated})\ \frac{\pi}{2}\sqrt{\frac{c_p}{c_E}}.$$

$$\therefore\ \theta = 90 \times \sqrt{\frac{45}{185}} = 44{\cdot}3 \text{ degrees approx.}$$

$$\therefore\ \cot\theta = 1{\cdot}02;\ \frac{\pi}{2\theta} - \operatorname{cosec}\theta = 2{\cdot}04 - 1{\cdot}43 = {\cdot}61.$$

$$\therefore\ B_E \text{ is greater than } B_c.$$

Next take the other end of the practical range of values, say $\frac{l}{g} = 260$. We shall show later that upon certain assumptions a limiting value for c_p in this case is 12·2 and $c_E = 4{\cdot}38$.

$$\therefore\ \theta = 90 \times \sqrt{\frac{12{\cdot}2}{4{\cdot}38}} = 150 \text{ degrees approx.}$$

$$\cot\theta = -1{\cdot}73;\ \frac{\pi}{2\theta} - \operatorname{cosec}\theta = {\cdot}6 - 2 = -1{\cdot}4.$$

In this case also therefore B_E is greater than B_c, and we may take it that for all intermediate values this will be the case.

For $\frac{l}{g}=120$, for instance, we may take $c_p = 33{\cdot}6$ and $c_E=20{\cdot}6$.

$$\therefore\ \theta=90\times\sqrt{\frac{33{\cdot}6}{20{\cdot}6}}=115^\circ \text{ approx.}$$

$$\cot\theta=-{\cdot}466 \quad \frac{\pi}{2\theta}-\operatorname{cosec}\theta={\cdot}78-1{\cdot}10=-{\cdot}32$$

We shall explain later how we obtained the values of c_p given above; the negative values are to be explained by the fact that $(\pi^2-m^2l^2)$ is also negative when $\cot\theta$ is negative, the combined effect giving a positive result.

Formula for ultimate Strength of Pillar.—By equating the combined direct and bending stress at the ends of the pillar to the yield-point stress c_y we have

$$c_y=\frac{W}{A}+\frac{B_E n}{Ag^2}$$

$$=\frac{W}{A}\left\{1+\frac{e_o n}{g^2}\cdot\frac{\pi\, ml}{(\pi^2-m^2l^2)}\cot\frac{ml}{2}\right\} \qquad (26)$$

$$=c_p\left\{1+\frac{e_o n}{g^2}\cdot\frac{2\,\theta}{\pi\left(1-\frac{4\theta^2}{\pi^2}\right)}\cot\theta\right\}$$

$$=c_p\left\{1+\frac{e_o n}{g^2}\cdot\frac{2\,\theta}{\pi\left(1-\frac{c_p}{c_E}\right)}\cot\theta\right\} \qquad (27)$$

$$=c_p\left\{1+\frac{e_o n}{g^2}\frac{\sqrt{c_p c_E}}{(c_E-c_p)}\cot\theta\right\} \qquad (28)$$

$\therefore$ Writing as before $\alpha=\frac{e_o n}{g^2}$ and $Q=\frac{c_p}{c_y}$ = pillar stress coefficient, we have

$$Q=\frac{1}{\left\{1+\frac{\alpha\sqrt{c_p c_E}}{(c_E-c_p)}\cot\theta\right\}} \qquad (29)$$

This formula is very troublesome to use because we can solve it for given values of α and $\frac{l}{g}$ only by a process of trial and error by taking values of c_p until the two sides agree.

It is interesting to note that when $\frac{l}{g}$ is very small equation (27) approaches the value :

$$c_y\doteq c_p\left\{1+\alpha\,.\,\frac{2\,\theta\cot\,\theta}{\pi}\right\}$$

$$=c_p\left\{1+\frac{\alpha\,.\,2}{\pi}\right\}\text{ approx.} \qquad (30)$$

APPROXIMATION FOR SOLUTION OF EQUATION 29. We will now investigate the effect of assuming that a *pillar fixed at the ends and initially slightly bent is equivalent as regards ultimate strength to a hinged pillar of the same section but of half the length and half the initial eccentricity.*

We shall find that for most practical purposes the result of equation (28 for the given pillar with fixed ends is the same as that of equation (14) for the assumed pillar.

TABLE II —Eulerian Functions

Values of C	$\frac{\zeta}{g}$ = 40		$\frac{\zeta}{g}$ = 50		$\frac{\zeta}{g}$ = 60		$\frac{\zeta}{g}$ = 70		$\frac{\zeta}{g}$ = 80		$\frac{\zeta}{g}$ = 90		$\frac{\zeta}{g}$ = 100	
	Sin θ	Cos θ	Sin θ	Cos θ	Sin θ	Cos θ	Sin θ	Cos θ	Sin θ	Cos θ	Sin θ	Cos θ	Sin θ	Cos θ
1	·1152	·9933	·1438	·9896	·1723	·9850	·2007	·9797	·2289	·9735	2569	·9664	·2847	·9586
2	·1626	·9867	·2027	·9792	·2425	·9701	·2819	·9594	3208	·9471	·3592	·9332	·3970	·9178
3	·1987	·9801	·2474	·9689	·2955	·9553	·3429	·9394	3894	·9211	·4350	·9004	·4794	·8776
4	·2289	·9735	·2847	·9586	·3395	·9406	·3932	·9194	·4456	·8952	·4965	·8680	·5458	·8379
5	·2553	·9669	·3172	·9484	·3777	·9259	·4366	·8996	·4938	·8696	·5488	·8359	·6016	·7988
6	·2791	·9603	·3462	·9381	·4116	·9113	·4750	·8800	·5360	·8442	·5943	·8042	·6496	·7602
7	·3008	·9537	·3727	·9280	·4424	·8968	·5095	·8605	·5737	·8191	·6345	·7729	·6916	·7222
8	·3208	·9471	·3970	·9178	·4705	·8824	·5409	·8411	·6077	·7941	·6705	·7419	·7288	·6848
9	·3395	·9406	·4196	·9077	·4965	·8680	·5698	·8217	·6387	·7694	·7029	·7113	·7618	·6479
10	·3571	·9341	·4407	·8976	·5207	·8537	·5964	·8027	·6671	·7450	·7322	·6811	·7913	·6115
11	·3737	·9276	·4606	·8876	·5434	·8395	·6211	·7837	·6932	·7207	·7589	·6512	·8177	·5756
12	·3894	·9211	·4794	·8776	·5646	·8253	·6442	·7648	·7174	·6967	·7833	·6216	·8415	·5403
13	·4044	·9146	·4972	·8676	·5847	·8113	·6658	·7461	·7397	·6729	·8056	·5924	·8628	·5055
14	·4187	·9081	·5142	·8577	·6037	·7972	·6861	·7275	·7605	·6493	·8261	·5635	·8820	·4712
15	·4325	·9017	·5304	·8478	·6216	·7833	·7051	·7091	·7798	·6260	·8448	·5350	·8992	·4375
16	·4456	·8952	·5458	·8379	·6387	·7694	·7231	·6907	·7979	·6028	·8620	·5069	·9147	·4042
17	·4583	·8888	·5606	·8281	·6550	·7557	·7401	·6725	·8147	·5799	·8778	·4791	·9285	·3714
18	·4705	·8824	·5748	·8183	·6705	·7419	·7561	·6545	·8304	·5572	·8922	·4516	·9407	·3392
19	·4823	·8760	·5885	·8085	6853	·7283	·7713	·6365	·8450	·5347	·9055	·4244	·9516	·3074
20	·4938	·8696	·6016	·7988	·6994	·7147	·7856	·6187	·8587	·5124	·9176	·3976	·9611	·2762
21	5048	·8632	·6143	·7891	·7130	·7012	·7992	·6010	·8715	·4904	·9286	·3711	·9694	·2454
22	·5155	·8569	·6265	·7795	7261	·6876	·8121	·5835	·8835	·4685	·9386	·3450	·9766	·2151
23	·5259	·8505	·6382	·7698	7384	·6744	·8244	·5660	·8946	·4469	·9477	·3191	·9827	·1853
24	·5360	8442	·6496	·7602	·7503	·6611	·8360	·5487	·9050	·4254	·9559	·2936	·9878	·1559
25	·5458	8379	6607	·7507	·7618	·6479	·8470	·5316	·9147	·4042	·9633	·2684	·9919	·1271
26	·5553	8316	·6713	·7412	·7728	·6347	·8575	·5145	·9237	·3832	·9699	·2436	·9951	·0987
28	·5737	·8191	·6916	·7222	·7935	·6086	·8768	·4808	·9398	·3417	·9808	·1948	·9991	·0433
30	·5911	·8066	·7108	·7034	·8126	·5828	·8943	·4475	·9536	·3011	·9891	·1472		
32	·6077	·7941	·7288	·6848	·8304	·5572	·9099	·4148	·9652	·2613	·9949	·1009		
34	·6236	·7817	·7458	·6662	·8469	·5318	·9240	·3824	·9750	·2221	·9985	·0556		
36	·6387	·7694	·7618	·6479	·8620	·5069	·9365	·3507	·9829	·1841	·9999	·0120		
38	·6532	·7572	·7769	·6296	·8761	·4821	·9476	·3194	·9892	·1467				
40	·6671	·7450	·7913	·6115	·8891	·4577	·9574	·2886	·9939	·1100				
42	·6804	·7328	·8048	·5935	·9012	·4334	·9661	·2583	·9973	·0741				
44	·6932	·7207	·8177	·5756	·9123	·4095	·9736	·2284	·9992	·0389				
46	·7055	·7087	·8299	·5579	9226	·3858	·9800	·1989	1·0000	·0045				
48	·7174	·6967	·8415	·5403	·9320	·3624	·9854	·1700						
50	·7287	·6848	·8524	·5228	·9407	·3392	·9899	·1414						
52	·7397	·6729	·8628	·5055	·9487	·3163	·9935	·1135						
54	·7503	·6611	·8727	·4883	·9559	·2936	·9963	·0858						
56	·7605	·6493	·8820	·4712	·9625	·2712	·9983	·0586						
58	·7704	·6376	·8909	·4543	·9685	·2491	·9995	·0318						
60	·7798	·6260	·8992	·4375	·9739	·2272	1·0000	·0056						
62	·7890	·6144	·9072	·4208	·9787	·2055								
64	·7979	·6028	·9147	·4042	·9829	·1841								
66	·8064	·5913	·9218	·3878	·9866	·1629								
68	·8147	·5799	·9285	·3714	·9899	·1420								
70	·8227	·5685	·9348	·3551	·9926	·1214								

TABLE III.—Eulerian Functions continued.

Values of C	$\frac{\zeta}{g}$ = 110			$\frac{\zeta}{g}$ = 120			$\frac{\zeta}{g}$ = 130			$\frac{\zeta}{g}$ = 140			$\frac{\zeta}{g}$ = 150		
	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ
1	3122	9500		3395	9406		3665	9304		3932	9194		4196	9077	
2	·4341	·9008		·4705	8824		·5062	8624		5409	·8411		5748	8183	
3	5277	8525		5646	8253		6052	7961		6442	7648		6816	7317	
4	5933	8050		6387	·7694		6820	7313		7231	·6907		·7618	6479	
5	6518	·7583		6994	·7147		7441	·6681		·7856	6187		8239	·5667	
6	·7017	·7124		·7503	·6611		·7951	6064		8360	·5487		8727	·4883	
7	·7447	·6674		7935	6086		8376	·5463		8768	4808		9110	·4125	
8	·7822	·6231		·8304	·5572		·8731	·4876		9099	4148		9407	3392	
9	8149	·5795		8620	·5069		9026	·4304		9365	·3507		·9633	2684	
10	·8437	·5368		8891	·4577		9271	·3747		9574	2886		9798	2001	
11	8690	4948		·9123	·4095		9473	3204		9736	2284		9909	1343	
12	8912	4536		9320	3624		·9636	2675		9854	1700		·9975	0707	
13	9107	·4131		9487	3163		9764	2160		9935	1135		1·0000	·0035	
14	9277	3734		9625	·2712		·9861	1659		9983	0586				
15	·9424	3344		·9739	·2272		9931	·1171		1·0000	·0056				
16	9552	2961		9829	·1841		9976	0696							
17	9660	2586		·9899	·1420		9997	0235							
18	·9751	2217		9949	·1009										
19	·9826	·1856		9982	·0608										
20	9887	·1501		·9998	·0216										
21	·9933	·1154													
22	·9967	·0813													
23	·9989	·0479													
24	·9999	·0152													

Values of C	$\frac{\zeta}{g}$ = 160			$\frac{\zeta}{g}$ = 170			$\frac{\zeta}{g}$ = 180			$\frac{\zeta}{g}$ = 190			$\frac{\zeta}{g}$ = 200		
	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ	Sin θ	Cos θ	Cot θ
1	4456	8952		4713	8820		4965	8680		·5214	8533		5458	8379	
2	6077	7941		6396	7687		6705	7419		·7002	7140		7288	6848	
3	7174	6967		7513	6600		7833	6216		·8134	5817		8415	5403	
4	7979	6028		·8313	5558		8620	5069		8898	4563		9147	·4042	
5	8587	5124		8900	4560		9176	3976		9413	3376		9611	2762	
6	9050	4254		9328	3604		9559	2936		9743	2253		9878	1559	
7	9398	3417		9631	2690		9808	·1948		9929	1194		9991	·0433	
8	9652	2613		9833	·1817		·9949	1009		9998	·0195				
9	9829	1841		9951	0984		9999	0120							
10	9939	1100		9998	·0183										
11	9992	·0389													
12															
13															
14															
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16															
17															
18															
19															
20															
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22															
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24															

The following results were obtained:—

TABLE IV.

a	$\frac{l}{g}=0$		$\frac{l}{g}=100$		$\frac{l}{g}=200$	
	Q (assumed).	Q (correct).	Q (assumed).	Q (correct).	Q (assumed).	Q (correct).
·05	·98	·97	—	—	—	—
·10	·95	·94	·93	·95	·61	·61
·20	·91	·89	·87	·91	·57	·57
·30	·87	·84	—	—	—	—
·50	·80	·79	·74	·72	·50	·50

As these calculations are of rather an unusual nature, it may be of interest to show how the results are obtained. Equation (29) is an example of what mathematicians call a "transcendental equation"; it cannot be solved directly; we can only take trial values of c_p and see if the two sides of the equation agree; if they do not, we must try something else until they do.

Take, for example, $\frac{l}{g}=200$ and $\frac{e_0 n}{g^2}={\cdot}20$; from *Fig.* 2 we see that for a hinged pillar for $\frac{l}{g}=100$ and $\frac{e_0 n}{g^2}={\cdot}10$, $Q={\cdot}57$.

$$\therefore\ c_p={\cdot}57\times 45=25{\cdot}65\,;\quad c_E=7{\cdot}40 \text{ (from Table I.).}$$

$$\therefore\ c_E-c_p=-18{\cdot}25.$$

$$\theta=90\sqrt{\frac{c_p}{c_E}}=90\times 1{\cdot}8618$$

$$=90+77{\cdot}562.$$

$$\therefore\ \cot\theta=-\tan 77{\cdot}562=-4{\cdot}533.$$

$$\therefore\ \frac{a\sqrt{c_p c_E}}{(c_E-c_p)}\cot\theta=\frac{{\cdot}2\,(\sqrt{25{\cdot}65\times 7{\cdot}40})}{-18{\cdot}25}\times -4{\cdot}533$$

$$={\cdot}685.$$

$$\therefore\ Q=\frac{1}{1{\cdot}685}={\cdot}593.$$

Next try $Q={\cdot}58$; then $c_p=26{\cdot}10$; $c_E-c_p=-18{\cdot}70$.

θ comes to $90^\circ+79{\cdot}024$; $\cot\theta=-5{\cdot}145$.

$$\therefore\ \frac{a\sqrt{c_p c_E}}{(c_E-c_p)}=\frac{{\cdot}2\sqrt{(26{\cdot}10\times 7{\cdot}40)}}{-18{\cdot}70}\times -5{\cdot}145$$

$$={\cdot}764.$$

$$\therefore\ Q=\frac{1}{1{\cdot}764}={\cdot}567.$$

This is nearly as much below our assumed result as our previous one was above; if we took $Q={\cdot}575$ we should find that the two sides of equation (29) came into very close agreement, so that for practical purposes we may regard ·57 as correct.

NOTE.—The following printer's errors have been noted in the first part of these articles (March 1918):—

P. 123, equation (9): e should be e_0 and in subsequent formulæ up to (10).

do. equation (11): d_n should be e.

do. *l.* 3 should read $\frac{c_p}{c_y}$ instead of $\frac{c_y}{c_p}$

(*To be continued.*)

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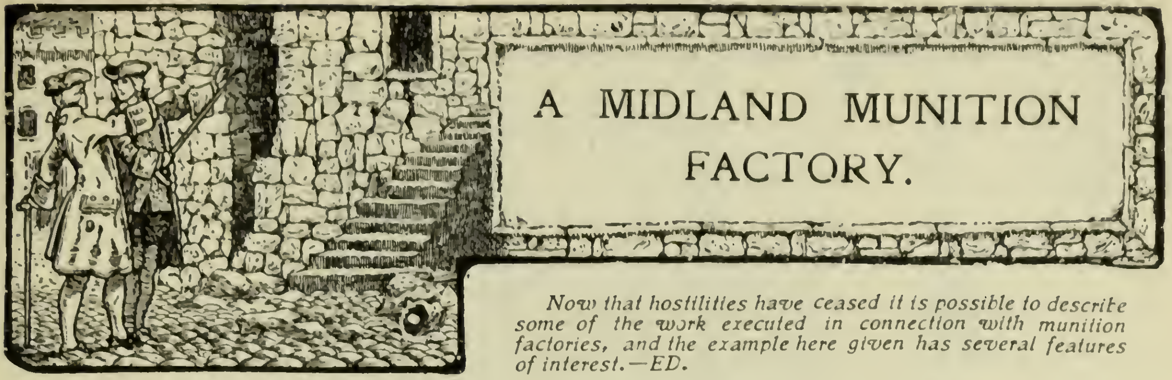
A MIDLAND MUNITION FACTORY.



Now that hostilities have ceased it is possible to describe some of the work executed in connection with munition factories, and the example here given has several features of interest.—ED.

By ALBERT LAKEMAN, M.S.A.

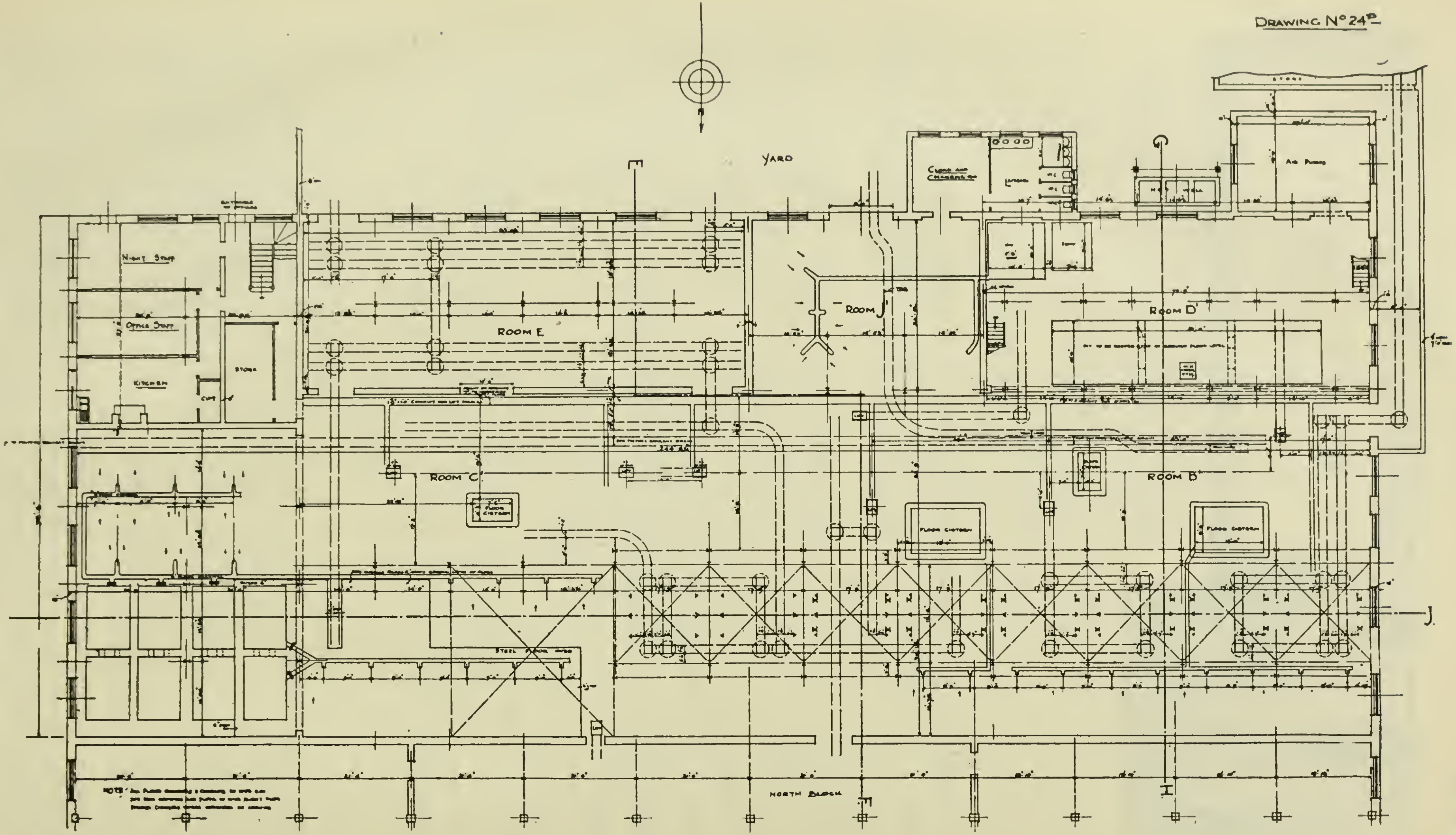
(*Concluded.*)

THE SOUTH BLOCK.

THE south block, which is separated from the north block by a brick wall for the whole of its length and height, is 246 ft. by 98 ft. 6 in. and the general arrangement of this is indicated on the plan illustrated in *Fig.* 9, and a section of one portion is given in *Fig.* 10.

The construction generally in this part of the building consisted of brick walls, steel framing and reinforced concrete floors, the latter being generally formed with slabs carried by ordinary rolled-steel joists with the latter cased in concrete, in which wire binding was placed. One of the chief features consisted of eight steel-framed towers, which were erected in one range over 140 ft. long and about 25 ft. wide. At the top of these towers a cast-iron water-tank, having a capacity of 150,000 gal., was erected and the height from the underside of the grillage foundation to the top of the tank is over 80 ft. The design and construction of these towers was naturally governed by the plant to be installed and the method of working generally. The main supports consist of a compound stanchion at each corner, built up with 12-in. by 6-in. r.s.j.'s and 12-in. by ½-in. plates, and they were made in three lengths. Outside this main framing and situated 2 ft. 8 in. away, is a second frame, built up with 8-in. by 6-in. by 35-lb. r.s. stanchions and 7-in. by 3-in. channels. These channels occurred at about every 4 ft. in the height, both in the main framing and the outer frame, as indicated in the section, and these had the effect of stiffening the structure apart from their use in connection with the process. An inner well in each tower was also formed with six stanchions built up with angles and running for the full height. The external walls of the towers were formed with 4-in. Cranham slabs built in between the 7-in. by 3-in. channels, after the latter has been protected with concrete, and these slabs were plastered on the inside and rendered externally with Portland cement and washed sand with the addition of Pudlo, and in spite of the large surface and exposed position of the work it proved perfectly watertight and no cracks have occurred.

Owing to the number of stanchions, the loads that had to be carried and the effect of the wind on the long sides of the towers, it was necessary to provide a continuous grillage foundation, especially as sand pockets occurred in some



- GROUND FLOOR PLAN -

Fig. 9. Plan of South Block.
A MIDLAND MUNITION FACTORY.

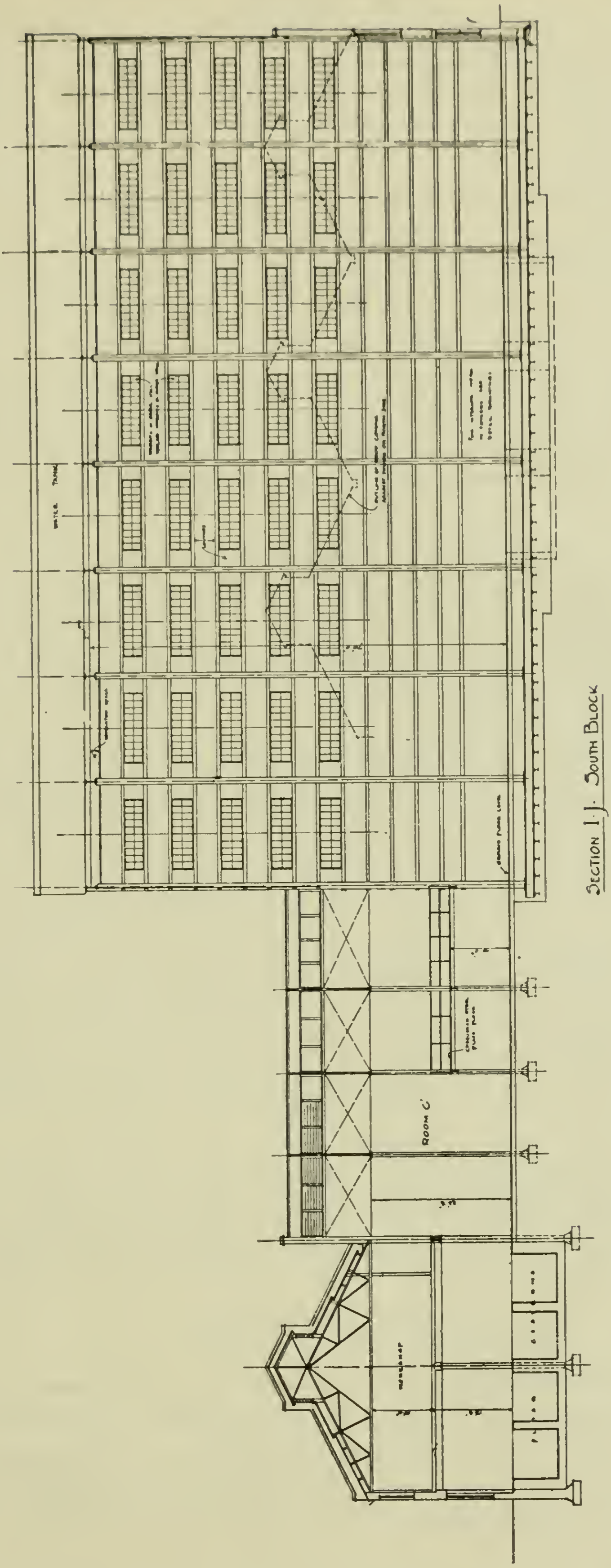


Fig. 10. Section of South Block.
A Midland Munition Factory.

parts of the subsoil. The bottom layer running across the towers consists of 16-in. by 6-in. r.s.j.'s and on these were placed the longitudinal girders which formed the seating for the stanchion bases. A compound section was adopted under the main stanchions, two 12-in. by 5-in. by 32-lb. r.s.j's, under the outer, 8-in. by 6-in. stanchions and one 12-in. by 6-in. by 44-lb. under each of the interior angle stanchions. The whole of this grillage was concreted in with mass concrete, the underside of which is 7 ft. below the floor level and stiffeners, tie rods and distance pieces were employed in the grillage beams to give one large rigid frame. Owing to the avidity with which certain of the materials and liquids used during the process attacked steel and concrete it was necessary to provide a protection for some distance above the floor, and this was accomplished by casing the members with concrete and covering the latter material with special acid-resisting asphalt, and this was found quite effective. A horizontal layer was also provided to prevent any percolation to the grillage work. These towers required considerable thought in their design and execution as they are very complicated and many difficulties had to be overcome, owing to the special nature of the plant and machinery for which they are used. Special ventilation had also to be provided, and they may be considered unique as they were the first of their kind to be erected in the world. It is interesting to note that a large quantity of asbestos sheets were used for special purposes in connection with the plant, and although they were exposed to strong liquids and very rough usage they proved very satisfactory.

Several floor cisterns and tanks were constructed below the floor level of the south block and all these were constructed with reinforced concrete.

The largest of these is 51 ft. long inside and it is roofed over at the floor level with a reinforced concrete slab 8½ in. thick, the span being 12 ft. The outer walls are 1 ft. 5 in. thick, reinforced with a single lattice of steel rods placed 6 in. from one surface, and the bottom is 6 in. thick with reinforcement in both directions, and the rods from the bottom, sides and roof are connected at the junctions. The roof over the south block is constructed with steel trusses spaced at about 14-ft. centres, and they are similar in type to those used for the north block, except that provision for hanging loads on the tie beams was unnecessary, and the clear height from floor to underside of tie beam is generally 23 ft. 6 in., to allow for the special plant. Several steel-framed floors were required at various points for the support of apparatus which, in many cases, consisted of castings weighing over 10 tons, and in addition provision had to be made for vibration and shock, which necessitated heavy sections and a large amount of bracing.

THE STATION FOR UNLOADING.

The unloading station, which is 100 ft. long by 30 ft. wide, is constructed with steel-latticed stanchions to carry the crane girders, which have a span of 33 ft. 4 in., and the eaves joists, which support the steel roof trusses, spaced at 10-ft. centres. This station is arranged to serve the siding and pick up materials either from the railway trucks direct or from the tram lines adjoining, and quick and easy handling was achieved.

GRINDING HOUSE.

The grinding house, which is a two-storey building, is entirely steel-framed, with $4\frac{1}{2}$-in. brick panel filling rendered externally and plastered on the inside, and the first floor was constructed with rolled-steel joists and reinforced concrete slabs. Numerous holes were required in this floor, and these were formed during the casting of the concrete with special framing and reinforcement, as required. Provision against movement under the vibration caused by the plant was made by the introduction of double-angle braces between the stanchions and the main floor beams, and this proved quite satisfactory.

OTHER BUILDINGS.

The majority of the other stores and outbuildings generally were constructed with brickwork and steel, the latter being employed for the floors and the roofs; and although in some cases the features were somewhat unusual no special notes are necessary here.

WATER SUPPLY.

The water supply to the factory is obtained from a fast-running stream about 500 yards away from the main buildings and situated in a valley about 70 ft. lower than the factory ground-floor level. A pumping station was erected in a convenient position on the bank of this stream, and the water was raised by electrically-driven pumps supplied with current from the factory power-house. In order to maintain an adequate supply of water on the factory site for circulating purposes and in case of fire a storage reservoir of 375,000-gal. capacity was constructed, this being additional to the 150,000 gal. provided in the tower tank.

This reservoir is 100 ft. square and the water is 6 ft. deep, but it was necessary to build the walls 10 ft. high on account of the existing ground levels, and the construction employed was practically a combination of mass concrete and reinforced concrete. The reinforcement consisted of small diameter rods arranged to form a lattice in the sides and bottom near the inner surface, the object of these being to prevent cracks occurring. The method of construction proved very satisfactory, and the reservoir remained perfectly watertight, even when used as a cooling pond for large quantities of very hot water.

DRAINAGE.

The drainage from the factory and power-house was dealt with under four systems—viz., rain water, sewage, chemical waste and boiler drainage. The first-mentioned was taken to the reservoir and the other three were treated in special installations on the factory site before the effluent was allowed to pass into an adjacent stream. A septic-tank installation was put in to deal with the sewage and concrete was employed throughout for the tanks and filter beds, this being plain concrete mixed in the proportion of 4 parts fine granite, 2 parts sand and 1 part cement, a thickness of 9 in. being the minimum generally employed. The use of concrete in this work was decided on owing to its adaptability to the various shapes required and also to the need of making the various compartments watertight.

The tanks for the chemical waste and boiler drainage were also formed in concrete, and although in the case of the former there was a tendency for the material to become pitted and eaten away after a time owing to the action of the strong liquids which passed into the tanks for recovery, there was no other material which could have been employed successfully for the purpose.

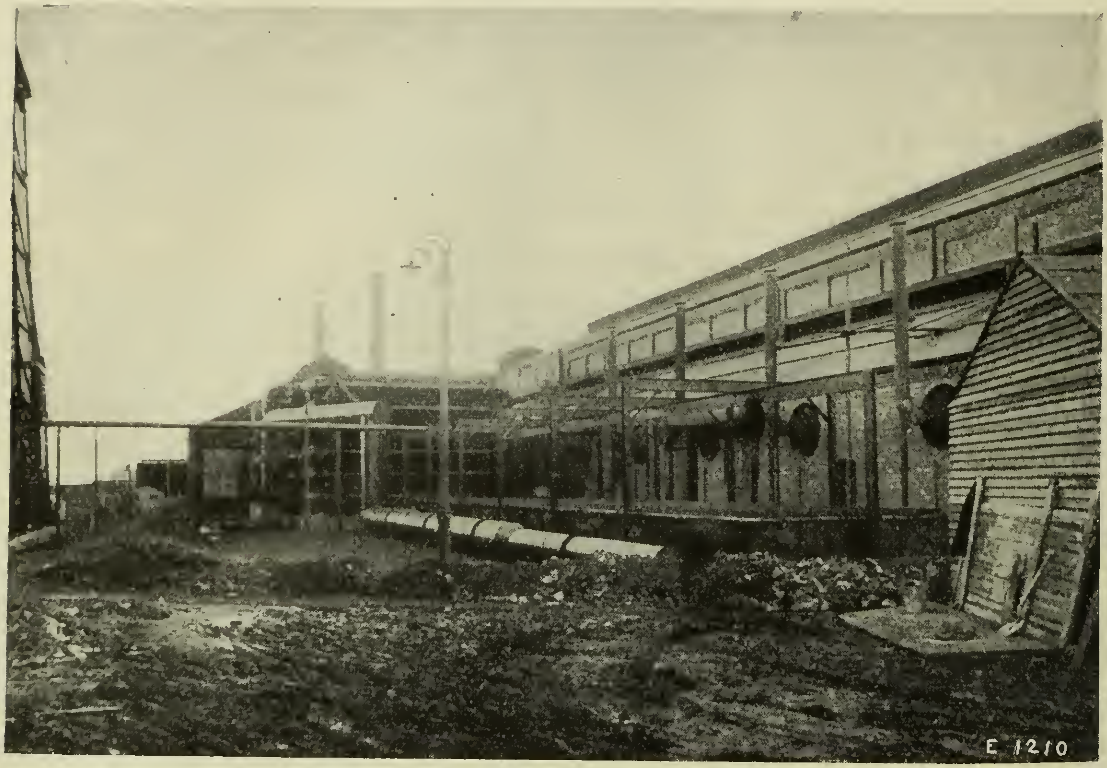


Fig. 11. Gas Cleaning Plant.

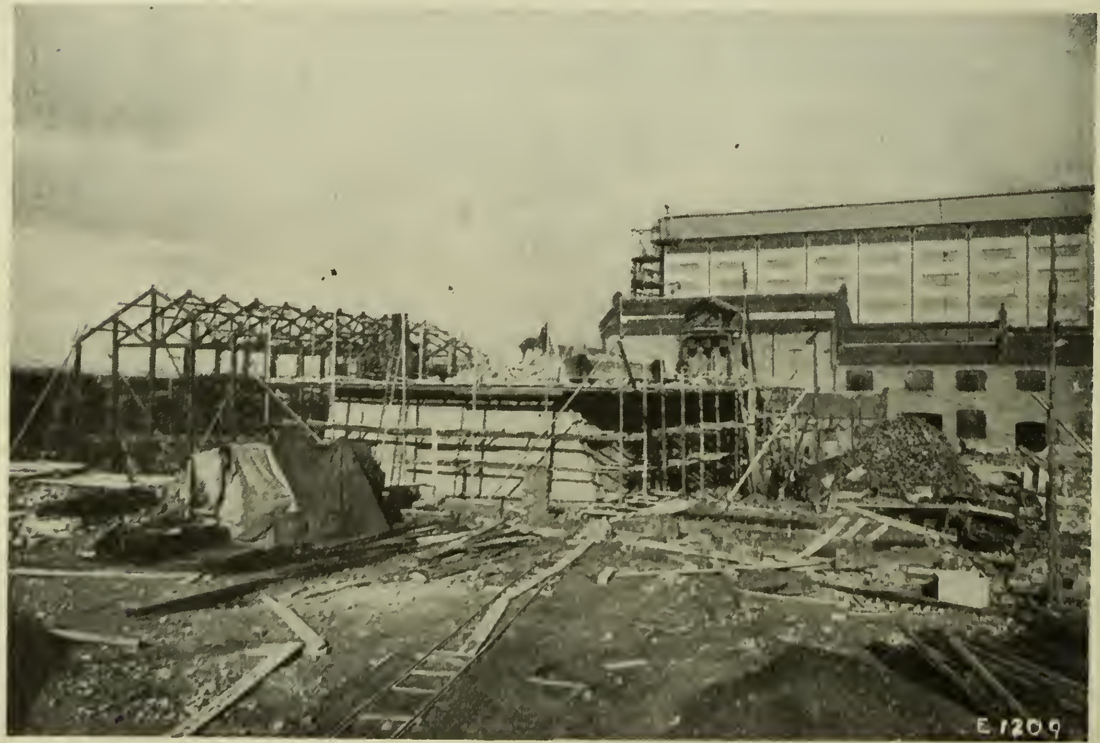


Fig. 11*a*. Steelwork to Grinding House.
A Midland Munition Factory.

GENERALLY.

It is interesting to note that the first materials delivered to the site were steel rods for reinforcement, and the portion of the buildings wherein reinforced concrete was most extensively employed was the first to be completed and ready for use. This is of some importance in indicating the possibilities of speed in connection with reinforced concrete construction, especially when it is considered

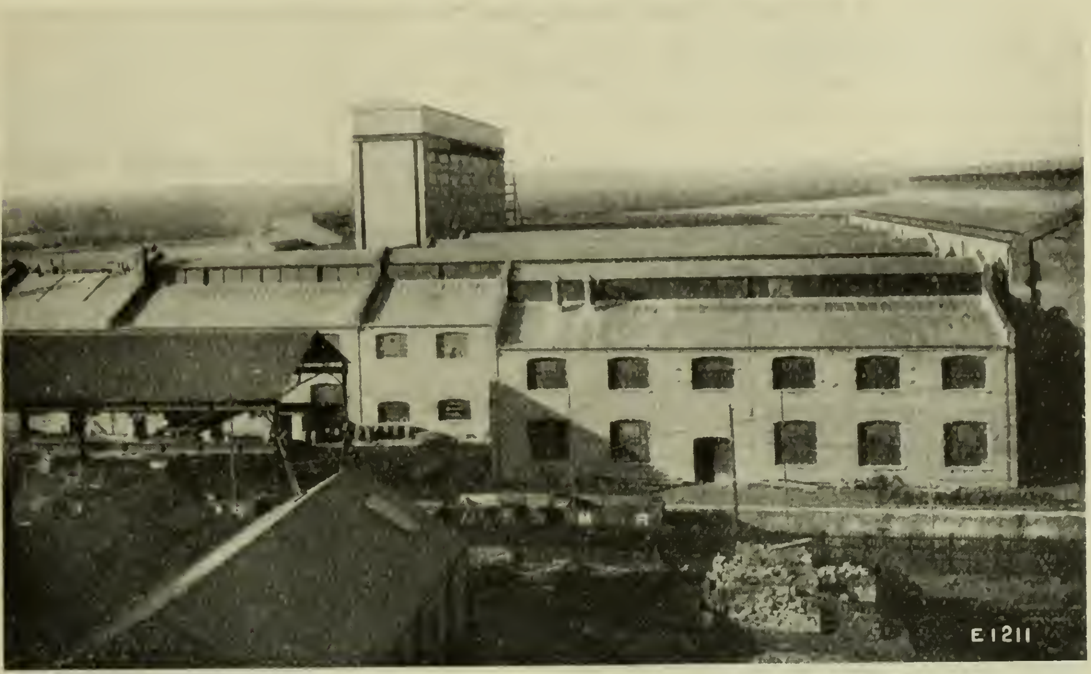


Fig. 12. View from East Side.

Fig. 13. View from S.W. Corner.
A Midland Munition Factory.

in conjunction with the fact that the work was commenced in November and bad weather was experienced.

The concrete for the reinforced work generally was composed of 4 parts of Leicester granite, 2 parts of Trent sand and 1 part of Portland cement, and the whole was machine-mixed.

The concrete for the wall foundations and similar work was composed of 4 parts of limestone—obtained from the site during the excavations and subsequently crushed—2 parts of red Mansfield sand and 1 part of Portland cement, all this being also machine-mixed.

Tests for compression and shear were made from time to time during the work and satisfactory results were obtained, the test pieces being made from the ordinary mix when leaving the machine without any previous warning to the foreman in charge of the work.

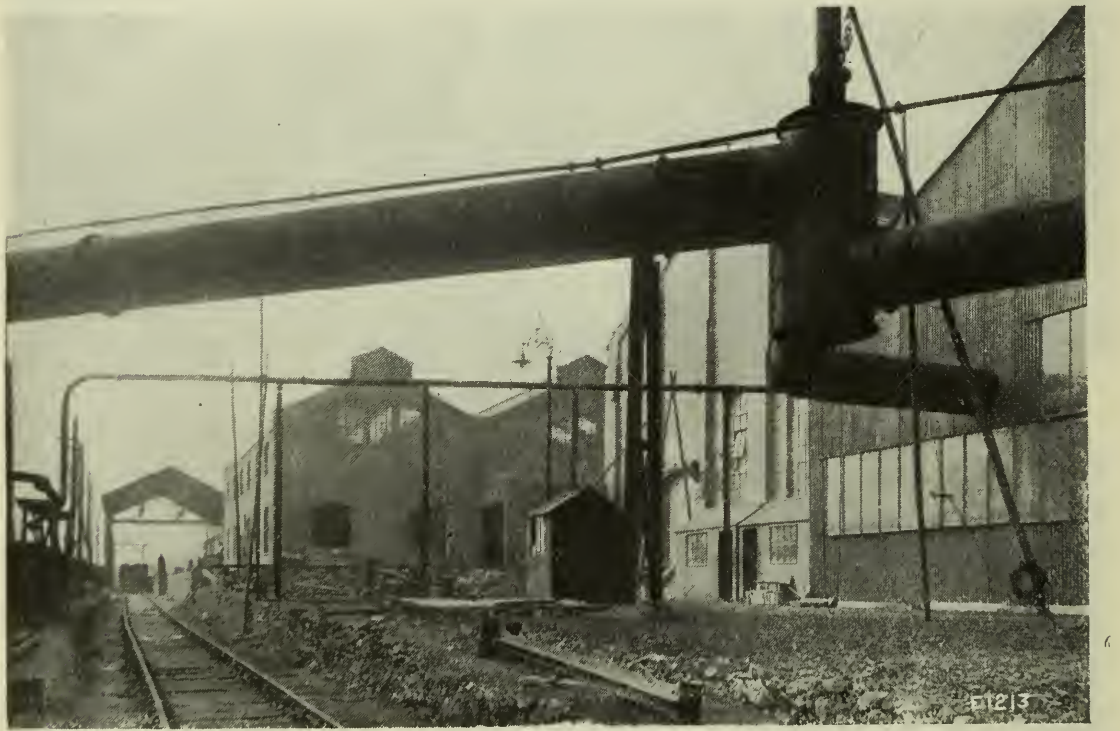


Fig. 14. View from N.E. Corner.
A MIDLAND MUNITION FACTORY.

Some photographic views of the factory during the latter stages of construction are given, but unfortunately no views are available of the earlier stages, where the interesting nature of the work could be seen.

The whole of the reinforced concrete and steelwork was designed and detailed by the architect and executed under his supervision.

The contractors for the factory buildings were Messrs. Holloway Bros., London, and they executed the whole of the reinforced concrete construction.

A village was erected in the vicinity of the factory for the housing of the workers, and this was also carried out to the designs of Mr. E. Keynes Purchase, the contractor for this work being Mr. John Greenwood, of Mansfield.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Messrs. Andrews and Beaumont, Patent Agents, of 204-6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of February, 1919.—ED.

Concrete Ships.—*No.* 123,802. *R. C. Bristow,* 9, *Boundaries Mansions, Boundaries Road, Balham, S.W.*12. *Dated February* 26/18.—This invention consists in manufacturing the shell of floating concrete vessels with transverse corrugations on the inside of the vessel and longitudinal corrugations on the outside, the object being to obtain a maximum of strength with a minimum of weight. Metal reinforcements may be embedded in the corrugations, so that a vertical corrugation is reinforced vertically and a longitudinal one in a longitudinal direction.

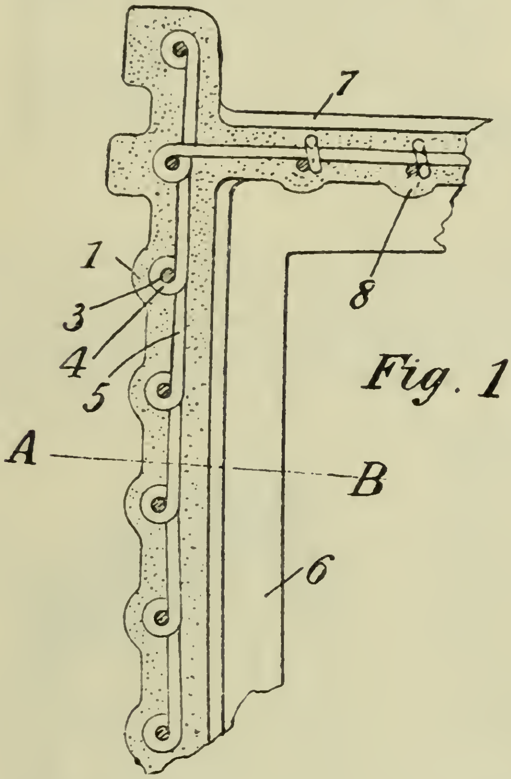


Fig. 1

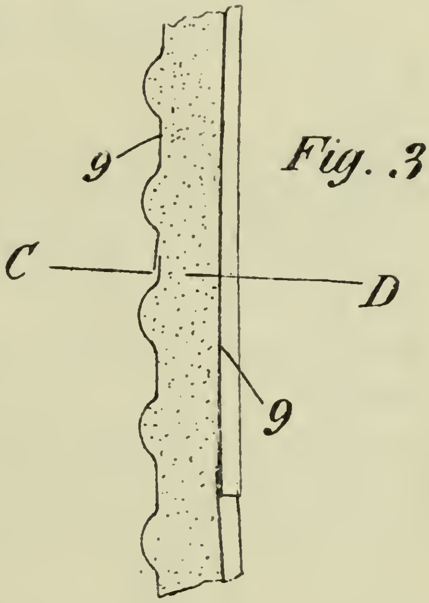
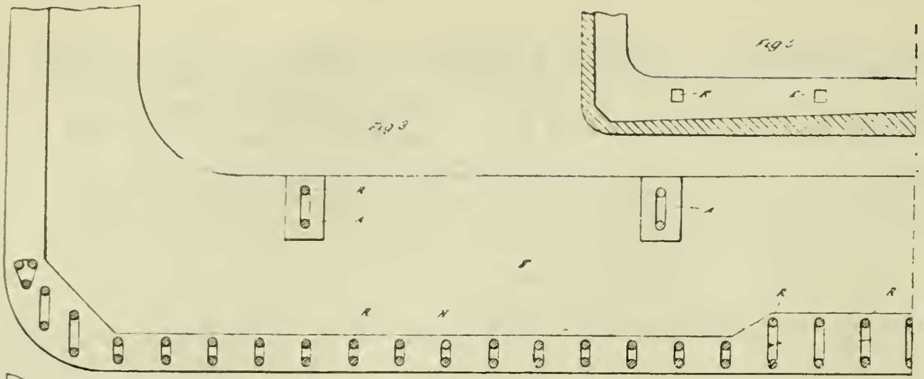


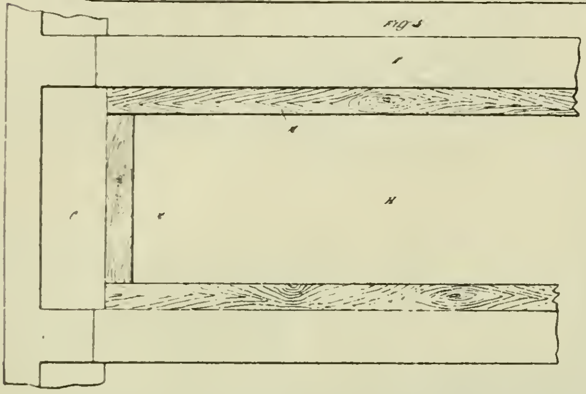
Fig. 3.

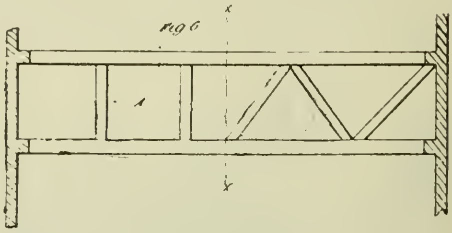
In *Figs.* 1 and 2 external corrugations (1) and internal corrugations (2) are shown reinforced by bars (3, 5), looped over each other ; the deck may be formed similarly. The shuttering employed in construction is corrugated, and when composed of iron sheets may be left as a permanent covering, distance bolts being employed to maintain the sides of the mould at the requisite distance apart during filling.

Concrete Ships.—*No.* 123,611. *T. A. J. Guerritte and L. G. Mouchel and Partners,* 38, *Victoria Street, S.W.*1, *and Ferro-Concrete Ship Construction Co., Ltd., Vickers House, Broadway, Westminster. Dated March* 12/18.—In accordance with this invention, keelsons in reinforced concrete ships are dispensed with, and longitudinal reinforcing bars (*R*) are placed in the skin to resist longitudinal main stresses in addition to local stresses. Longitudinal tie-beams (*A*) may be placed between the frames to stiffen them, or small longitudinal or diagonal beams (*A*), *Fig.* 6, may be employed and the bottom may be gradually thickened from the sides to the centre to avoid the use of beams.

The arrangement of the tie-beams near the upper part of the transverse frames facilitates the concreting of the bottom of the ship ; further, as such ties are not taken







into account for resisting the main longitudinal stresses of the ship, they need not be built in at the same time as the frames, but may simply be added after the frames have been concreted (the necessary recess having been left in the concrete). In this way the shuttering of the transverse frames may extend unbroken for the full width of the ship, as shown in *Fig.* 4, instead of having to be made in the form of rectangular boxing, as was previously the case.

Ferro-Concrete Structures facing Brickwork.—*No.* 123,210. *J. H. Williams, Shakespeare Street, Chorlton-on-Medlock, Manchester. Dated March* 23/18.—Tiles forming temporary or permanent centring for ferro-concrete structures, applicable also for facing brickwork, are formed on the inner face with a recess (a^3) on the upper edge, end projections (a^4) on the lower edge, and sockets or holes (a') to receive the ends of wire or rod ties (B). For walls, *Fig.* 1, the concrete filling is applied as the courses are laid. The sides of the tiles are grooved, dovetailed or recessed, as shown

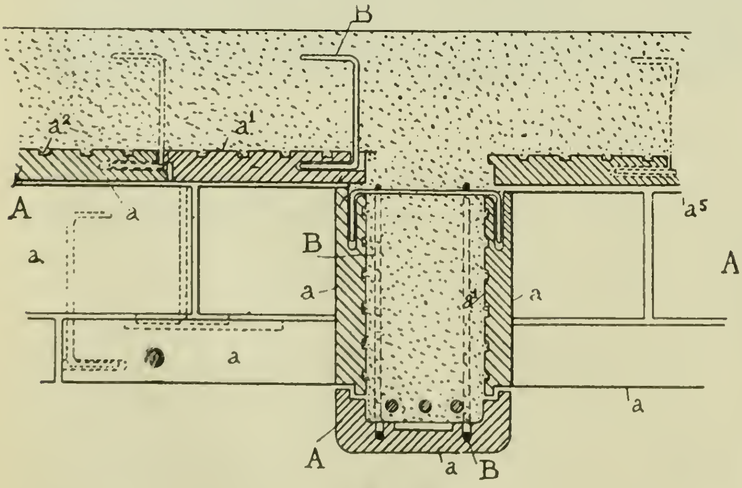
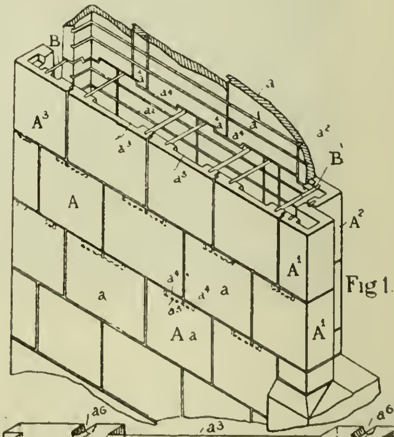
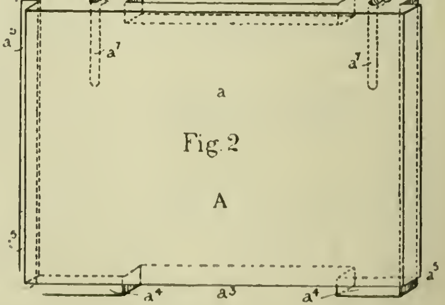


Fig.8.



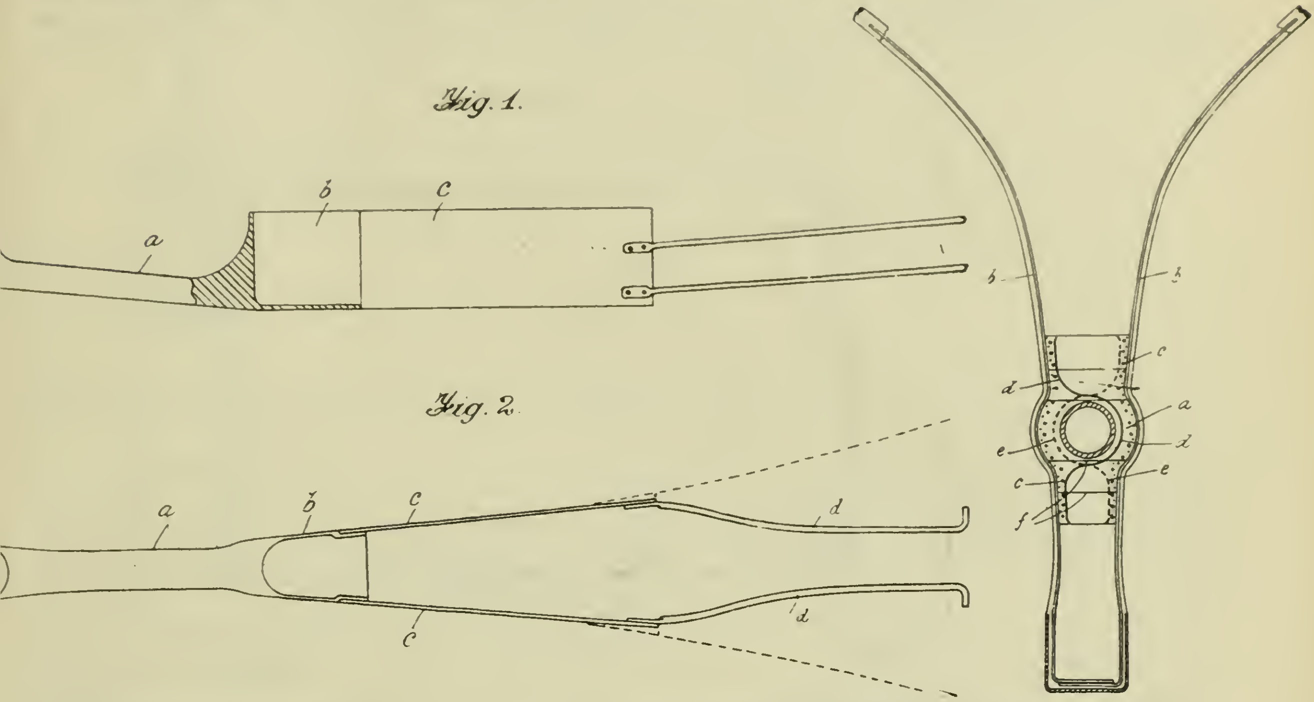


at a^5, and the inner faces are grooved or serrated to key with the filling. *Fig.* 8 shows a floor and ceiling, temporary supports and lagging being used until the concrete has set. Where the tiles are to form a temporary sheeting, the inner faces are smooth and the tie wires are omitted. The invention is applicable to the construction of reservoirs, tanks and ships.

Concrete Ships.—*Nos.* 123,433 *and* 123,432. *J. S. L. De Vesian and L. G. Mouchel and Partners, Ltd.*, 38, *Victoria Street, S.W.*1, *and the Ferro-Concrete Ship Construction Co., Ltd., Vickers House, Broadway, Westminster. Dated March* 12/18.—According to the first of these inventions the rudder of a reinforced concrete ship is partly supported on a steel member or horn (*a*), provided with flanges (*b*), to which a plate or plates (*c*), which extend in a rearward direction, are adapted to be attached or with which they may be cast; the plates, termed wing plates, are attached to the reinforced concrete structure by bolts or rivets.

Fig. 1.

Fig. 2.



Longitudinal reinforcing bars (*d*) in the sides of the ship extend horizontally to the stern of the ship between the wings; and are bent upwardly towards the boss through which the propeller shaft passes.

According to the second invention, the stern of the ship is provided with a boss (*a*) through which the propeller shaft passes. Vertical reinforcing bars (*b*) are placed near the surface of the concrete and are bent at the boss to conform with the contour of the surface.

Longitudinal reinforcing bars (*c*) are disposed inside or outside the vertical bar, or both, to follow the contour of the ship's sides; other reinforcing bars (*e*) pass from one side of the ship to the other and back to strengthen the concrete around the propeller shaft, and tie links (*f*) are also provided.

Reinforced Concrete.—*No.* 123,211. *N. Greening & Sons and N. Greening, Bewsey Road, Warrington, Lancashire. Dated March* 23/18.—A metal fabric for reinforcing concrete consists of plain bars (*a*) and transverse members (*b*) formed with cradles (*c*)

Fig. 1.

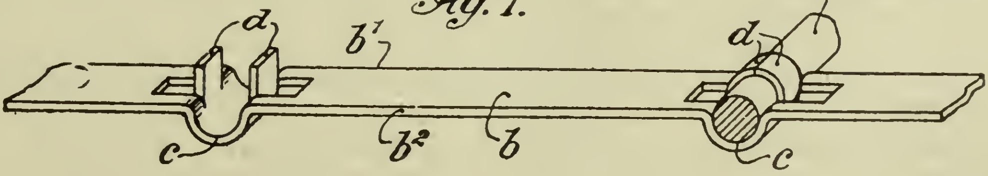
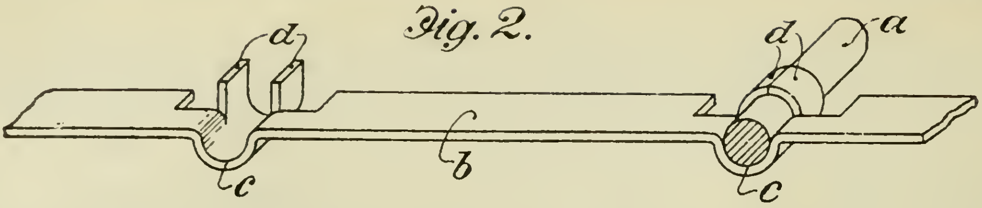


Fig. 2.



and pairs of tongues (*d*) pressed out of the wider face and closed over the bars (*a*) The tongues (*d*) may be formed on the same edge, or on opposite edges, or between the edges.

Concrete Ships.—*No.* 123,612. *C. R. J. Wood and L. G. Mouchel and Partners,* 38, *Victoria Street, S.W.*1, *and the Ferro-Concrete Ship Construction Co., Ltd., Vickers House, Broadway, Westminster. Dated March* 12/18.—According to this invention

Fig. 1.

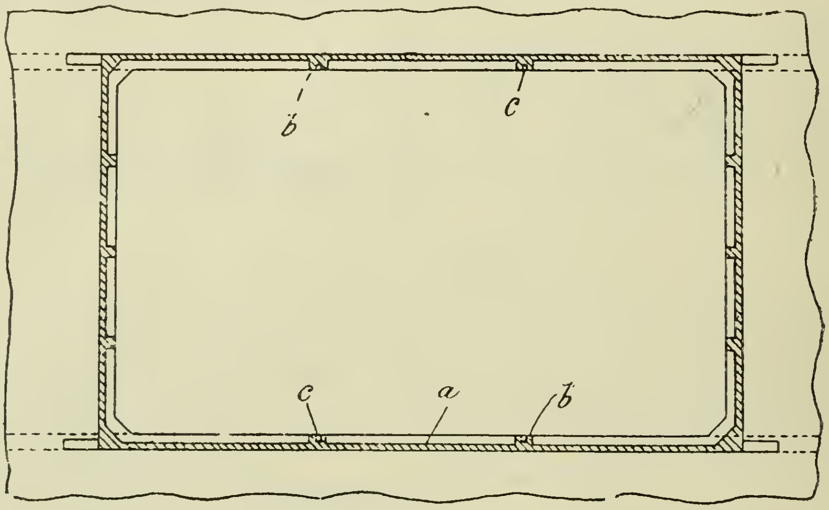


Fig. 2.

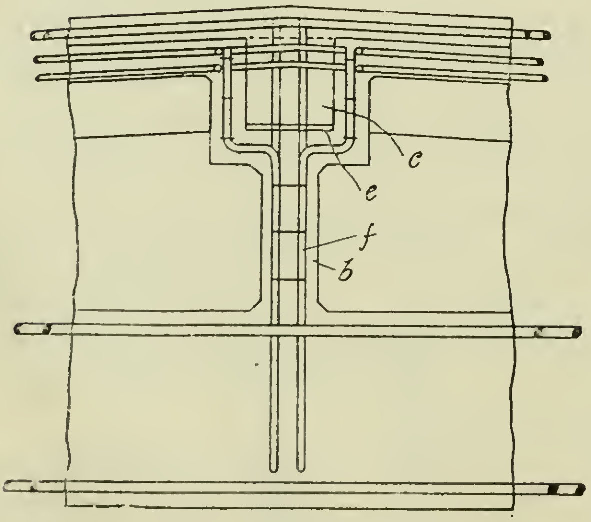
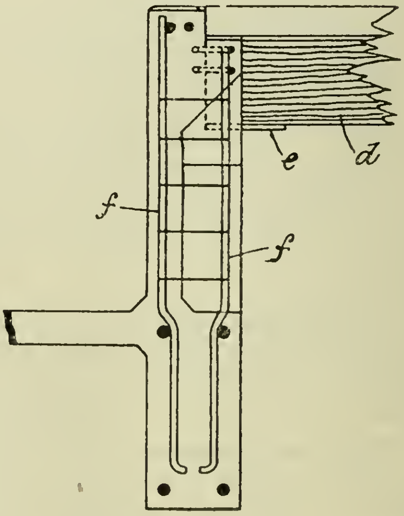


Fig. 3.



the hatch coaming (*a*) of reinforced concrete ships, barges, etc., is provided with counter posts (*b*); in each counter post is a vertical slot (*c*) adapted to receive the hatchweb (*d*), a bearing plate (*e*) being preferably provided for the web to rest upon. This bearing plate may be provided with holes through which the reinforcing bars (*f*) can be passed.

Reinforced Concrete.—*No.* 122,803. *P. A. Hinchliffe and H. Youel,* 14, *Regent Street, Barnsley. Dated September* 20/18.—Spacing members or ties for the main bars are constructed in accordance with this invention of round steel wire or rods bent into loops at intervals, and then stamped into wedge shape in cross-section between and adjacent to the loops. A flattening (*A*), incidental to the stamping, occurs at each side. The main bars, which may be square or round, and may be saw-toothed, are inserted in the loops and secured by wedges or welding.

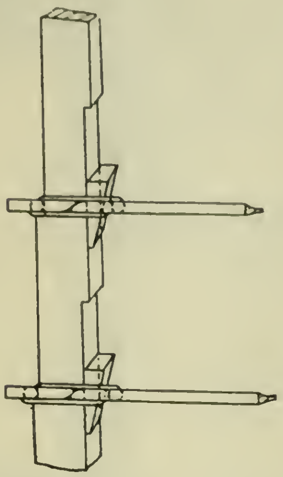


Fig. 4.

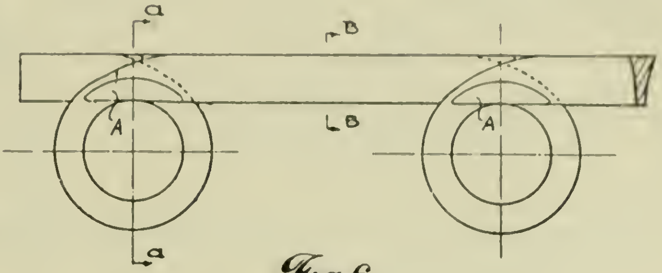


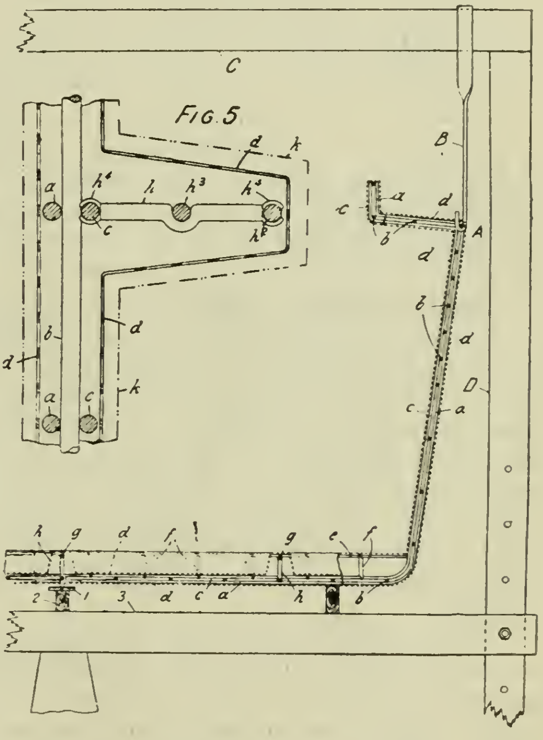
Fig. 6.

Concrete Ships, etc.—*No.* 123,595. *A. W. Hilliard*, 31, *Monson Road, New Cross Gate, S.E. Dated February* 28/18.—A method of constructing reinforced concrete floating structures in accordance with this invention without using shuttering consists in temporarily suspending a series of shaped vertical rods, connecting a series of horizontal rods and vertical stiffening bars thereto, covering one or both sides of the structure with expanded metal and applying concrete in one operation, so as to embed the metal in a mass of concrete. The vertical rods, preferably in single lengths, from the keel to the top of the deck coamings, are suspended from horizontal rods (*a*) shaped to the upper contour of the vessel and suspended by hangers (*B*) from beams (*c*). A series of longitudinal rods (*b*) is secured to the rods (*a*), and a further series of vertical rods (*c*) may be attached to the rods (*b*), or they may be suspended in the same manner as the rods (*a*).

Two series of longitudinal rods may be used, and stiffening bars consisting of simple rectangular bars or of rods tied together, as shown in *Fig.* 5, or surrounded by loops connected to the main framework, may be arranged behind some of the vertical rods. The structure is then covered with expanded metal (*d*), which may be corrugated and bent to include the stiffening members. Concrete is applied either by hand or by means of a blower or pump.

FIG. 1.

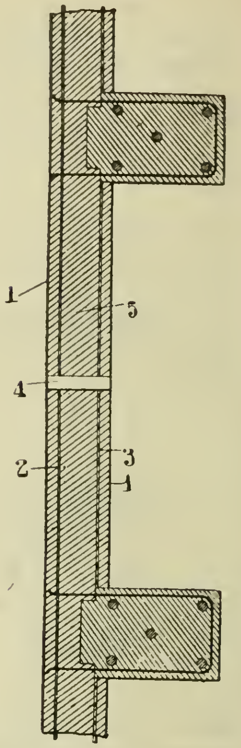
FIG 5



The keel may be provided with a double floor or keel formed by means of transverse and longitudinal rods—*e.g.*, supported by vertical clips (*f*, *h*) from the main reinforcement, and covered by expanded metal bent up and down to form a series of open rectangular chambers. The walls may have holes for drainage purposes, and may support a wooden or reinforced concrete floor. The deck coamings may be supported by reinforced concrete brackets.

Concrete Vessels.—*No.* 123,504. *J. C. Grant, Holly Lodge, The Terrace, Barnes, London. Dated February* 11/18.—A concrete ship is constructed by the use of flexible moulds (1) consisting of sheet metal or of canvas hardened, either before or after being placed in position, by treatment with cement. The moulds are placed on the inner and outer sides of metal meshwork (2, 3) associated with pre-cast frames, as shown, and are spaced by distance-pieces (4).

When the concrete has set the moulds are stripped off and, where canvas has been used, a smooth coating of cement is applied to obtain a smooth surface.



Shear Reinforcements. — *No.* 123,657. *E. O. Williams, "Shaston," Ardmore Road, Parkstone, Dorset. Dated May* 14/18.—To facilitate the placing in position and to prevent the slipping of stirrups for web reinforcement for reinforced concrete beams, etc., one on each end of the stirrup (*e*) is formed in accordance with this invention by bending the wire into an open hook of the form shown in *Figs.* 4 to 6. This enables the hook to be passed over the main reinforcing bar (*c*); then, by twisting the stirrup, the free end of the hook is caused to pass over and grip the bar.

An apparatus to facilitate the formation of the hook has three fixed stops, *g*, *g′* and *h*, *Figs.* 7 and 8, of which the last-mentioned has a spiral surface (*p*); the wire is placed against the stops (*g*, *g′*) and bent round the stop (*h*) and over the surface (*f*) to form the hook.

FIG 4

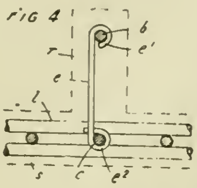


FIG 5

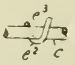


FIG 6

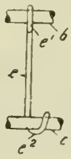


FIG 7.

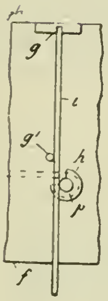
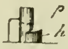


FIG 8



Ferro-Concrete Ships.—*No.* 123,558. *W. J. Stewart and J. Woolcock, 42, Albemarle Street, London. Dated February* 20/18.—In reinforced-concrete ships the reinforcement consists of two parallel networks, the transverse members of which comprise two elements or bars (*a*, *b*), spaced apart by inclined ties (*c*), such transverse members being adapted to be bent to the section of vessel without altering the spacing of the elements.

The elements may be corrugated to permit alteration of length when bending. The longitudinals (*d*, *e*) are supported in the angles between the elements and the ties, as shown. The ties may all slope in the same direction, and they may be bent around the elements (*a*, *b*); or the reinforcement may be formed by slotting and expanding the light double-bulbed rolled section shown in *Fig.* 5.

Fig.5

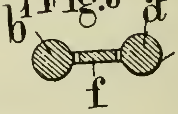
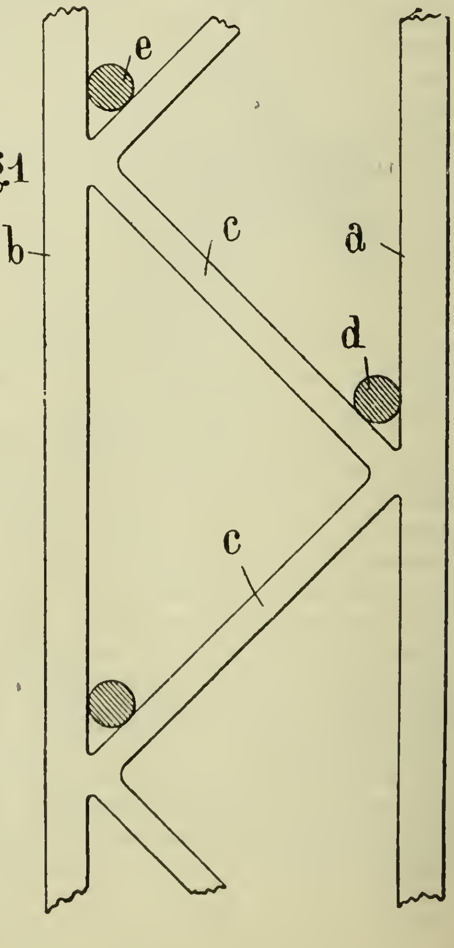
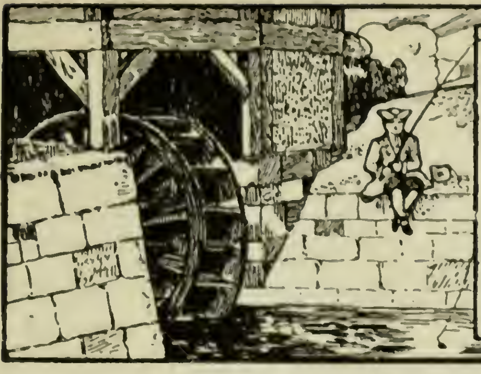


Fig.1





MINOR WORKS IN REINFORCED CONCRETE ON THE CALEDONIAN CANAL AT INVERNESS.

By EUSTACE W. PORTER, Assoc.M.Inst.C.E., etc., Resident Engineer.

Whilst the works described and illustrated in the accompanying reproduction from the working drawing are of a very minor character, they are perhaps a trifle exceptional in their application, and in consequence may interest readers, even being the means of suggesting somewhat similar substitutions where perishable materials have hitherto been employed.—ED.

THE work under description took the place of a timber hoarding, forming the boundary of one of the canal works yards, against which a lean-to timber roof existed. From the nature of the material, frequent repairs were necessary, resulting in a very unpresentable-looking and inconvenient structure.

The necessary entire renewal gave the opportunity for reconstruction in a really permanent material, and so arranging that the supports of the covering should give as much freedom of access as possible for storing canal maintenance plant. The adoption of cantilever beams also gave covered rack accommodation for ladders and other such items. The boundary wall piers, at 15 ft. centres, are built of hollow concrete blocks 1 ft. 6 in. square by 12 in. deep in 6 to 1 P.C. concrete grooved 6 in. by 1 in. deep on two sides, for receiving the walling blocks. Above the cantilever in each case the block is moulded solid for the sake of counter weight.

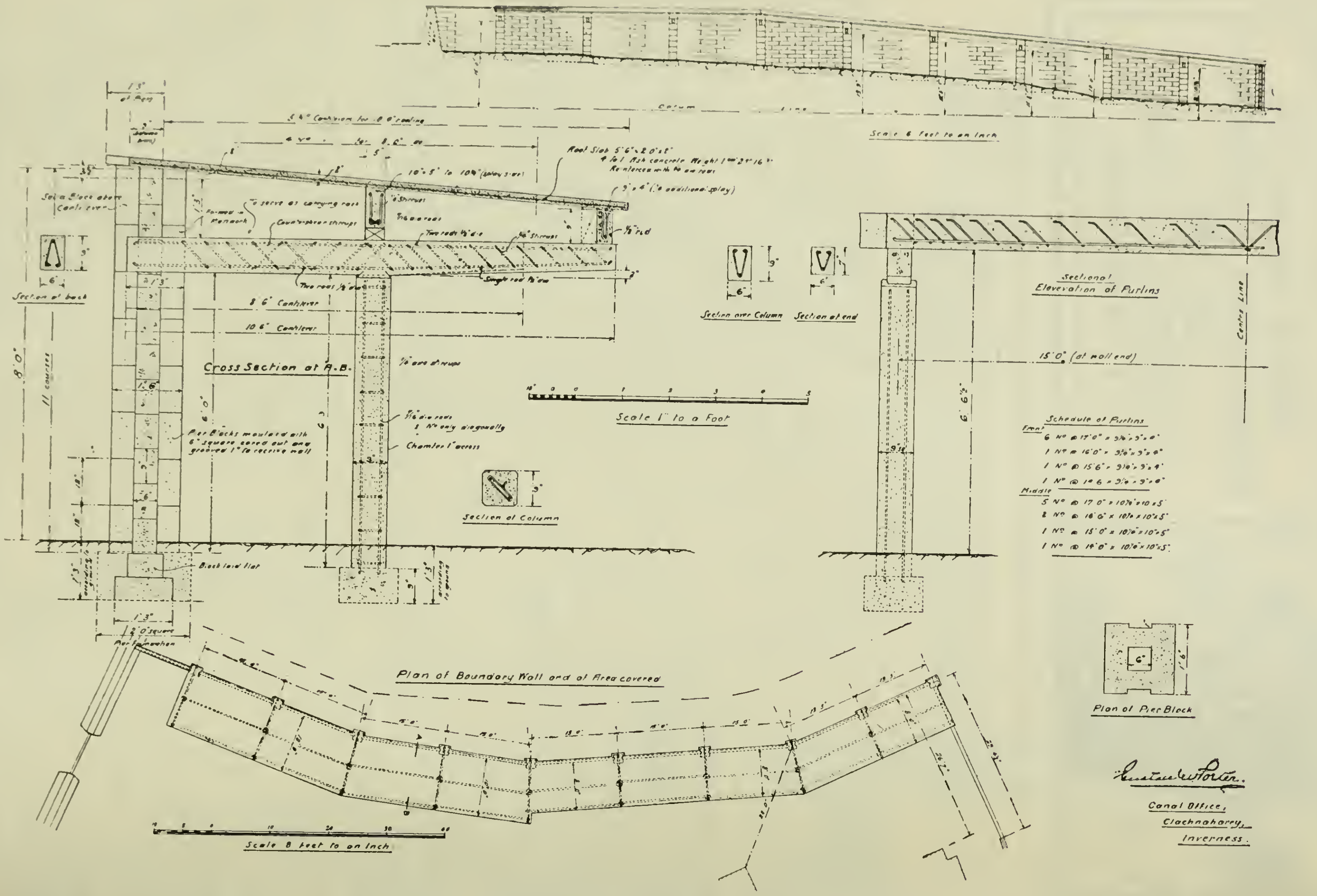
The walling between the piers is in moist moulded blocks of 4 to 1 P.C. concrete 2 ft. 8 in. by 9 in. by 6 in., exactly similar to those described in the article "Concrete Cottages in the Highlands" in the February issue of this journal (page 81 *ante*).

It will be seen from the reproduced drawing that the wall is neither straight in "plan" nor is the ground level for more than three bays in length.

The details of the reinforced columns, cantilevers and purlin beams are fully indicated in the line drawing, and call for no comment, except that the cantilevers have been designed to carry as rack members any stores that can be stowed upon them, and that the percentage of reinforcement in the purlin beams is low on account of the light nature of the roofing slabs.

The purlins are arranged to lap over one another in plan, hence the schedule length, so as to admit of a length using as few moulds as possible, and the simplest arrangement. All the above members are precast in the usual way of 4 to 1 P.C. concrete moulded wet.

Before settling on boiler ash concrete for the roofing slabs, two sample slabs, one of gravel concrete, and the other of ash concrete, were prepared for weighing and testing, the respective weights were 136 lb. and 91 lb. per cu. ft. As regards


Elevation of Wall and Roofing
Scale 6 feet to an Inch
Column Line
5' 4" Cantilever for 8' 0" roofing
Roof Slab 5' 6" x 2' 0" x 2"
4 to 1 Ash concrete Weight 1 cwt 2 qr 16 lb
Reinforced with 1/4" rods
10" x 5" to 10¾" (splay 3 ins)
9" x 4" (1/2" additional splay)
To serve as carrying rod
Formed in Monolith
Counterbraced stirrups
Two rods 1/2" dia
1/4" Stirrups
3/8" rod
Single rod 1/2" dia
Set a Block above Cantilever
Section of back
8' 6" Cantilever
10' 6" Cantilever
Cross Section at A.B.
Pier Blocks moulded with 6" square cored out and grooved 1" to receive wall
3/16" dia rods
1 No only diagonally
Chamfer 1" across
Section of Column
Block laid flat
1' 3"
2' 0" square
8' 0"
11 courses
6' 0"
9"
6"
Section over Column
Section at end
Sectional Elevation of Purlins
Centre Line
15' 0" (at wall end)
6' 6"
Scale 1" to a Foot
Schedule of Purlins
Front
6 No @ 17' 0" x 9¼" x 9" x 6"
1 No @ 16' 0" x 9¼" x 9" x 6"
1 No @ 15' 6" x 9¼" x 9" x 4"
1 No @ 14' 6" x 9¼" x 9" x 6"
Middle
5 No @ 17' 0" x 10¼" x 10" x 5"
2 No @ 16' 0" x 10¼" x 10" x 5"
1 No @ 15' 0" x 10¼" x 10" x 5"
1 No @ 14' 0" x 10¼" x 10" x 5"
Plan of Pier Block
1' 6"
Plan of Boundary Wall and of Area covered
Scale 8 feet to an Inch
Gustave Porter.
Canal Office,
Clachnaharry,
Inverness.

Minor Works in Reinforced Concrete on the Caledonian Canal.

the strength of a 2-in. thick slab, with ash as an aggregate, it was found that a two-months old 2 ft. wide slab reinforced with ¼-in. steel rods at 6-in. centre, over a span of 4 ft. 6 in., the maximum actually occurring, would carry a distributed load of one cwt. per lin. ft., with a deflection of ⅛ in., which was restored on the removal of the load.

The slabs are made in 2-ft. widths, in two lengths to butt over the purlin, and three edges V grooved and tongued. The front edge of the lower slab is throated, and the back edge of upper slab overlaps the piers and walling to form a coping.

The making-up width of slabs, necessary at each angle in plan, are formed *in situ*, on a narrow width of shuttering.

The joints of all roofing slabs are finally run with 1 to 1 P.C. grout.

The writer desires to express his indebtedness to the Canal Commissioners' Chief Engineer, Mr. L. John Groves, M.Inst.C.E., of Ardrishaig, for permission to publish an account of the above work.

A Concrete Road Bridge and Concrete Road in Ohio.

SOME NOTES ON CONCRETE ROADS.

The growing necessity of rebuilding many of our roads, and the opening up of new highways —now that the war is over—should cause us to turn greater attention to the use of concrete for this purpose. In presenting the various notes below of diverse activities in this direction, we would draw special attention to the decision of the Cardiff Council to use reinforced concrete for some of their roads.—ED.

Concrete Roads in Cardiff.—At a recent meeting of the Cardiff Public Works Committee, the city engineer, Mr. E. J. Elford, suggested that an experiment be made in reinforced concrete roads. He said that the repair of roadways was one of the biggest problems before the municipalities after the war, and, after a careful study of the whole subject, he had come to the conclusion that reinforced concrete should be used in the important streets. Thousands of miles of concrete roads had been made in America, with excellent results. One absolute condition was that the concrete must be left for four weeks after being laid without having the traffic turned on to it. Faced with tar, it would last for many years, with practically no cost of maintenance.

It gave a good foothold for horses ; it made a very " quiet " road as far as noises were concerned ; it did not wear into holes, but evenly, if the concrete was properly mixed, and he estimated that at a thickness of about 7 in. it would cost about 10s. a yard, as compared with 35s. a yard for wood-paving. He strongly recommended that St. Mary Street, High Street, and Bute Terrace be laid with concrete as soon as possible.

The committee discussed the matter from all standpoints, and they were so impressed with the information gleaned that they decided unanimously that the three thoroughfares named be concreted by direct labour.

Concrete Roads in Morrow County, Ohio.—Our illustration at the top of this page shows a concrete road bridge and part of a concrete road built in Morrow County, Ohio. The first part of this road was built in 1914, and only extended for a quarter of a mile, but in 1916 a contract was let for 6 miles of roadway.

Concrete Roads in Illinois.—In connection with concrete road construction in Illinois, as far as state-aided road work is concerned, the new regulations for 1919 contain the following provisions :—Consistency is rigidly defined. Broadly, it is to be " such that a conical pile of the concrete having a 45° slope will neither tend to flatten nor to run at the edges." It is to be such that the concrete will require " considerable tamping." It is required that precision of consistency be established by the following test : " A cylinder 6 in. in diameter and 12 in. in length shall be filled with concrete, which shall be tamped until all voids are filled and a slight film of mortar appears on the surface. The cylinder shall then be removed and the vertical settlement or slump of the concrete noted. This settlement shall not exceed 2 in. when the mechanical finishing machine is to be used, and shall not exceed 4 in. when the finishing is to be done by other methods permitted in the specifications."

Concrete is to be deposited the full depth of the slab and across the road in successive batches and then " it shall be levelled off and tamped mechanically with a machine approved by the engineers, until all voids are removed and the concrete is thoroughly compacted. The mechanical tamper shall go over each area of the pavment at least five times and at such intervals as will give the desired result." Hand tamping may be substituted for machine tamping, " providing at least four men are engaged at the exclusive work of tamping."

When machine tamping is employed the surface will be finished by two beltings, one given just after tamping and another just before initial set occurs. If hand-tamped, the slab is to be rolled once across and back and then a move forward of one-half the width of the roller, and then it is to be belted as with machine tamping. Specifications for belts and rollers and for their operation are the same as they have been previously.

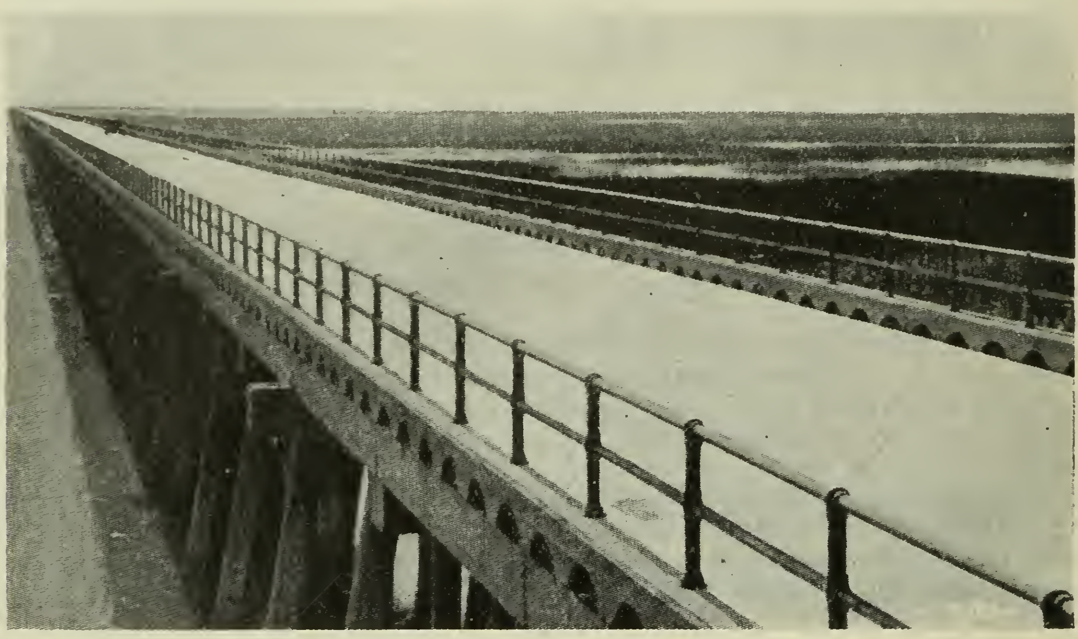
Special Preparation of Subgrade.—Special preparation of the subgrade is required for concrete roads. " The rolling and thorough compaction of the subgrade shall extend for a width of at least 12 in. beyond the edges of the pavement, and no backfill of any material excepting concrete will be permitted when re-rolling." In detail the accuracy of subgrade is to be determined as follows : " Immediately before any concrete is placed upon the subgrade it shall be tested for elevation by the use of a template riding on the side forms behind the mixer. In the lower edge of the template there shall be driven nails 6 in. apart and to such depths that their heads will just come to the true position of the subgrade when the template is riding on the forms. Testing the elevation of the subgrade shall be done by moving the template back and forth on the forms. On those areas of the subgrade found to be too high by as much as $\frac{1}{8}$ in., additional excavation shall be made until the required depth is reached, and the excavated material shall be deposited on the shoulders. Those areas below the true elevation shall be filled with concrete making an integral part of the slab proper ; all expense for this extra concrete including both labour and material shall be borne by the contractor."

Minor changes affecting equipment or construction methods are : Hauling over subgrade for greater distances than 500 feet is prohibited. When tamping machines are used the side forms must be steel. Removal of side forms after 12 hours is permitted. Mixers shall be equipped with automatic locks or time-recording devices which will prevent emptying until the batch has been mixed for the minimum time required.

Concrete for Railway Soft Spots.—The use of concrete slabs for bridging over soft spots in railway roadbeds was treated at considerate length in the report of the Committee on Ballast at the recent Chicago Convention of the American Railway Engineering Association. The method consists in the casting in place of a concrete slab under a part or all of the track where the soft place is located. This at first sounds expensive, but no forms are required, reinforcement is not absolutely necessary, and the mixture is comparatively lean.

Concrete Slabs for Railway Grade Crossings.—The Wayne County Road Commission, U.S.A., are giving serious consideration to the question of railroad grade crossings. Planks are becoming expensive, and, at their very best, have not been satisfactory for paving crossings. The coming type of crossing, says *Concrete* U.S.A., will be built of reinforced concrete slabs laid in place on top of the ties, and fitted at the joints with tar felt. This type of crossing will ride easily for passing vehicles, is in keeping with concrete roads, can be removed for ballasting track, and will not warp.

Concrete Causeway Across the Yolo By-Pass, California.—A short description of this causeway is given in a recent number of the *Concrete Highway Magazine.* This causeway crosses the Sacramento Valley, and has a total length of 14,000 ft. A great deal of material was used in its erection. Concrete piles were precast and allowed to harden 30 days before being driven. After they had been driven the piles were cut off to proper grade and concrete stringers to support the concrete floor slabs were put in place. The causeway is entirely of concrete. The piles weighed from 3 to 5 tons, and were driven from 15 to 25 ft. below ground level. The total weight of the trestle floor is 26,000 tons. Each unit or slab in the floor weighs 5 or 6 tons.



Concrete Causeway across Yolo By-Pass, California.

Concrete Pavement at a Gasoline Filling Station.—Our last illustration shows some concrete pavement around one of the gasoline filling stations at Glencoe, Ill. The heavy and varied traffic that uses the drives leading into and about gasoline filling stations in U.S.A. has demonstrated that substantial pavement is needed in improving them. Concrete appears to answer the purpose very well. In most instances the thickness should not be less than 8 in., and, preferably, 10 in. Well made, dense, properly finished concrete is stated to be proof against damage from oil drippings which accumulate on the pavement around the filling station.—*Highway Magazine.*

Concrete Pavement at a Gasoline Filling Station.

HOUSING NOTES.

The following are some brief notes dealing with various aspects of the housing question which may be of interest.—ED.

Concrete Cottages in Scotland.—In our December issue of last year, p. 655, we gave some short particulars and plans of a system for building cottages devised by Mr. Walter Wilson, of Dunfermline. The illustration *Fig.* 1, shows one of these cottages completed as erected in South Dewar Street, Dunfermline, whilst *Fig.* 2 (*see next page*), roughly indicates the details of construction. A feature of special significance in this form of construction is the entire elimination of plaster and slater work, and also outside plumber work. Wood work, too, is almost entirely deleted from the builder's estimates, unless such be required for ornamentation purposes. The beams are reinforced in a scientific manner. The upright blocks, which have no reinforcement, are made in ashlar faced by means of a machine that applies a stugged surface in granite marble, any other stone, or pea gravel, and is left entirely clean, showing the natural stone. The material is light, strong, attractive in appearance, and of proved durability. The method adopted under this construction is simple and easily erected.

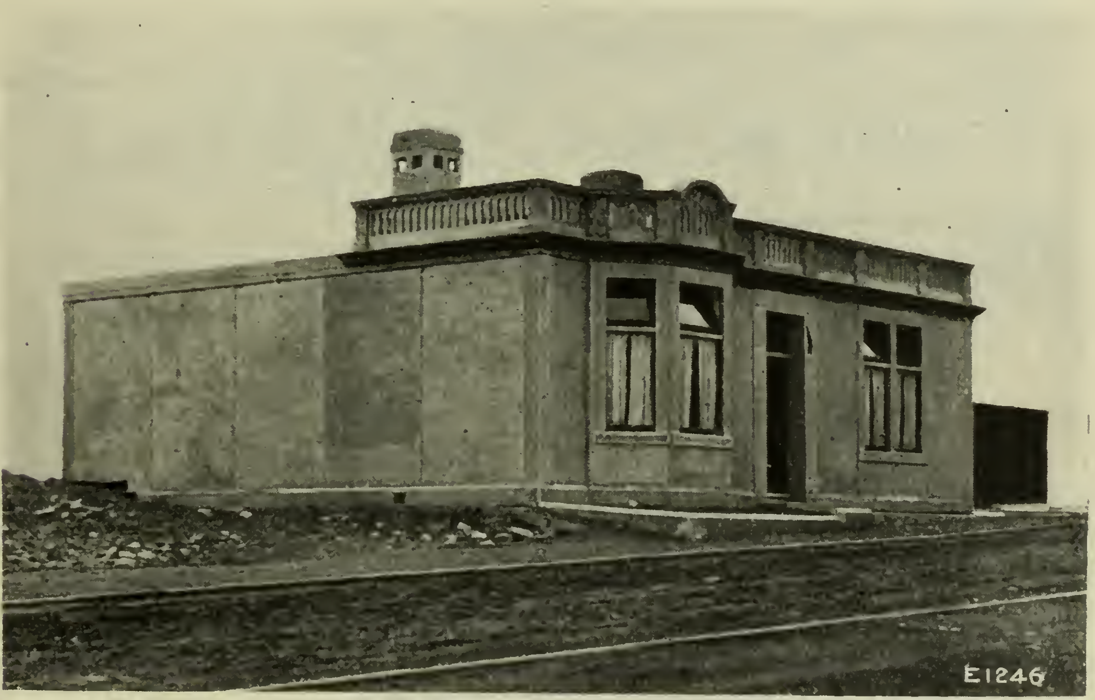


FIG. 1 FINISHED COTTAGE AT DUNFERMLINE.

Housing Suggestions.—The President of the Local Government Board invites information or suggestions as to economical or improved methods of construction suitable for small houses or any parts thereof, or as to fixtures and fittings. Particulars should be addressed to the Secretary, the Standardisation and Construction Committee, Housing Department, Local Government Board, Whitehall, S.W.1.

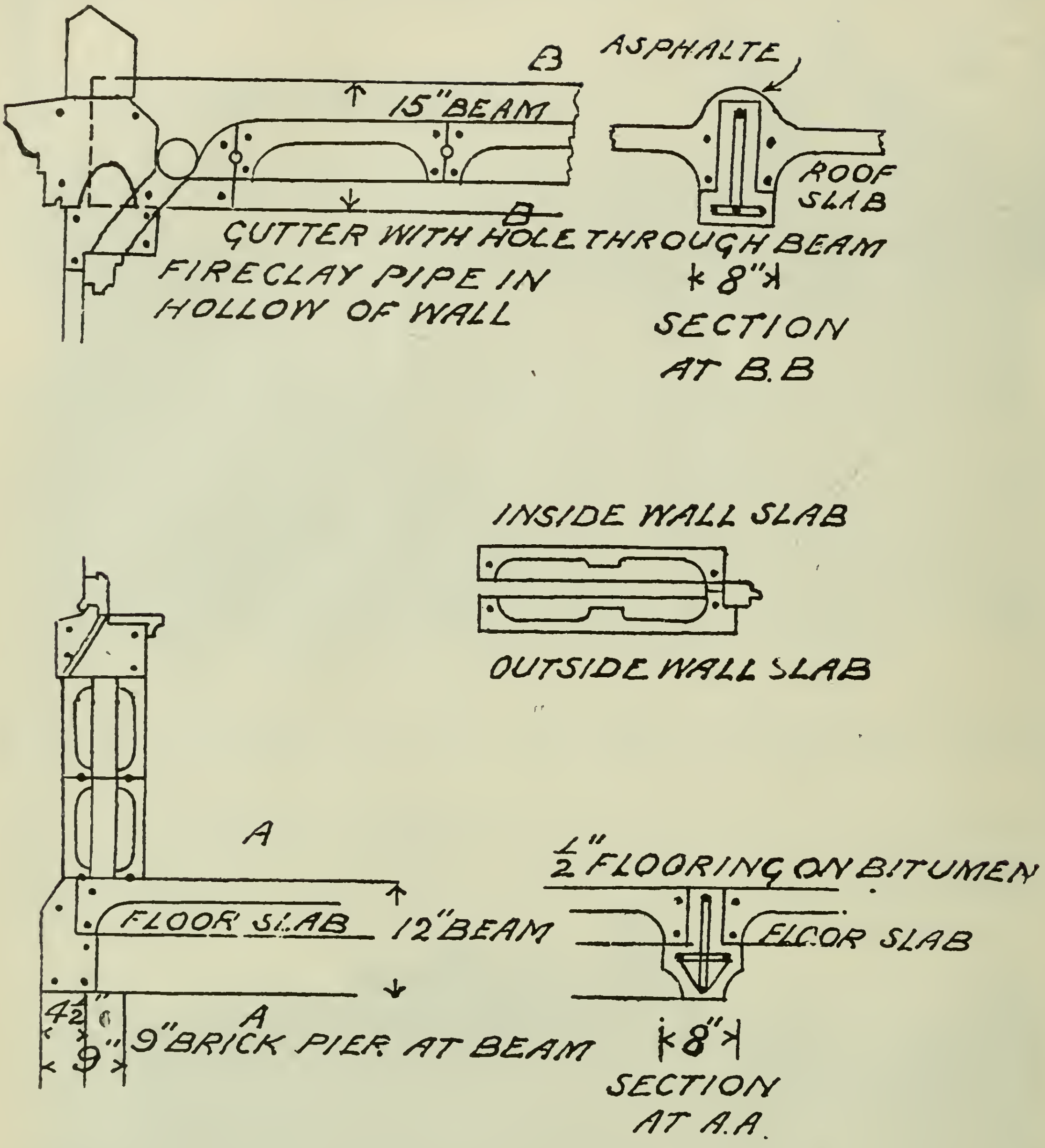


Fig. 2. Constructional Details of Dunfermline Cottage.

Model Homes Exhibition.—An interesting exhibition was opened last month at the Central Hall, Westminster, under the auspices of the *Daily Express* and *Sunday Express*. A number of models of cottages were shown, as well as plans and elevations. Other interesting exhibits included various fittings, stoves, accessories and labour-saving devices.

The promoters are to be congratulated upon having secured so central a position for this exhibition, which should do much to assist those who are about to undertake various housing schemes in different parts of the country.

The Exhibition closes on the 14th of this month.

Concrete Dwellings in Norway.—The accompanying illustrations show a system of reinforced concrete wall construction developed in Scandinavian countries previous to the war, and which is now being introduced in America. It provides a double air-space in a monolithic wall in three sections, the walls being tied together by

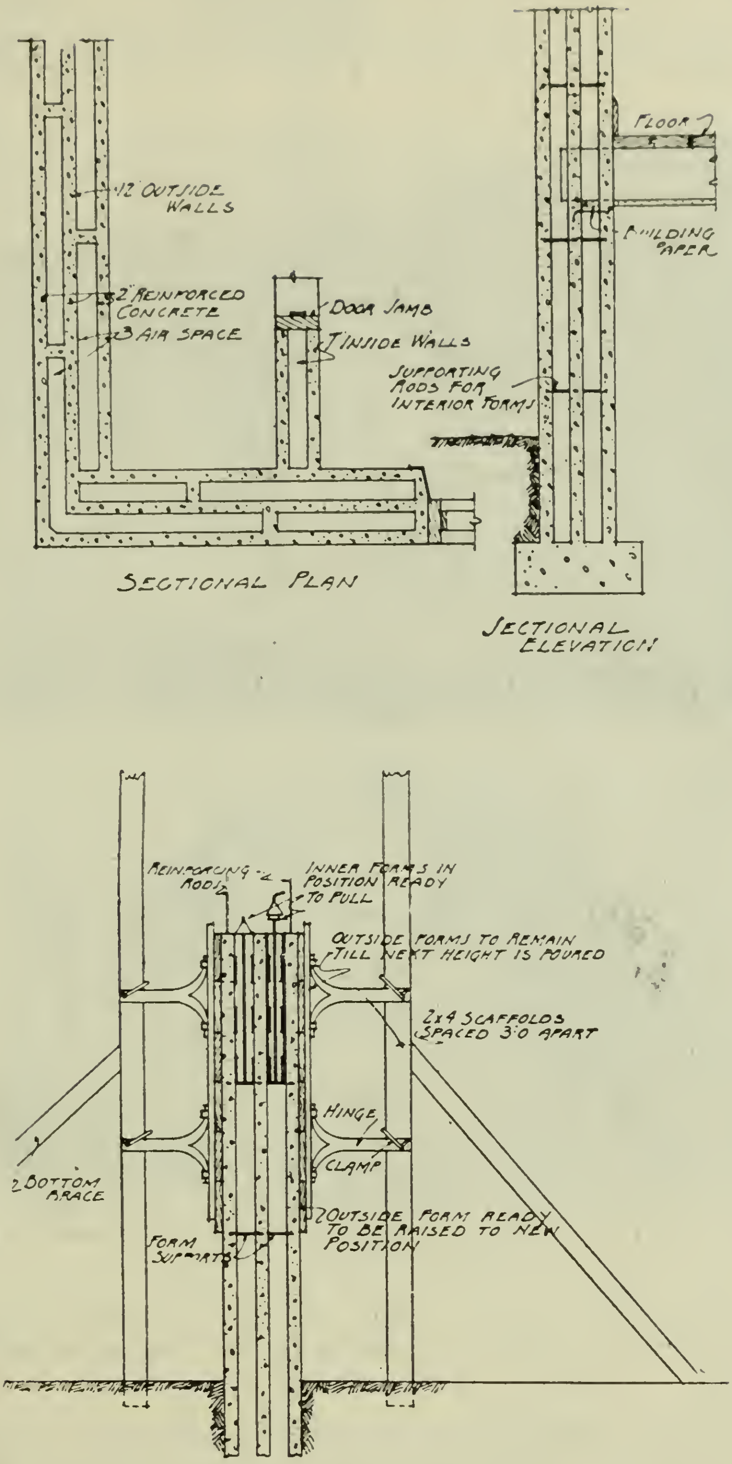

12" OUTSIDE WALLS
2" REINFORCED CONCRETE
3" AIR SPACE
DOOR JAMB
7" INSIDE WALLS
SECTIONAL PLAN
FLOOR
BUILDING PAPER
SUPPORTING RODS FOR INTERIOR FORMS
SECTIONAL ELEVATION
REINFORCING RODS
INNER FORMS IN POSITION READY TO PULL
OUTSIDE FORMS TO REMAIN TILL NEXT HEIGHT IS POURED
2x4 SCAFFOLDS SPACED 3'0" APART
HINGE
CLAMP
2 BOTTOM BRACE
FORM SUPPORTS
2 OUTSIDE FORM READY TO BE RAISED TO NEW POSITION

Fig. 3. Sectional Plan and Elevation of the Double Air-spaced Wall, and a Vertical Section showing the use of the Forms and necessary Scaffolding for Houses as erected in Sweden.
(*See next page.*)

light columns cast integrally and placed zigzag fashion, so that there is no direct line of conductivity to cause unnecessary decrease of insulating value. The construction as used gives a 12 in. wall consisting of three wall sections of 2 in. each, and two 3 in. air spaces. It is worked out with two tiers of exterior forms fastened to scaffolding by a flexible device as shown ; the interior forms are collapsible and are raised as each 2 ft. section of wall is cast. By using one set of interior forms or cores and two sets of outer forms, it is possible to construct 4 ft. of wall in height per day around an entire building.

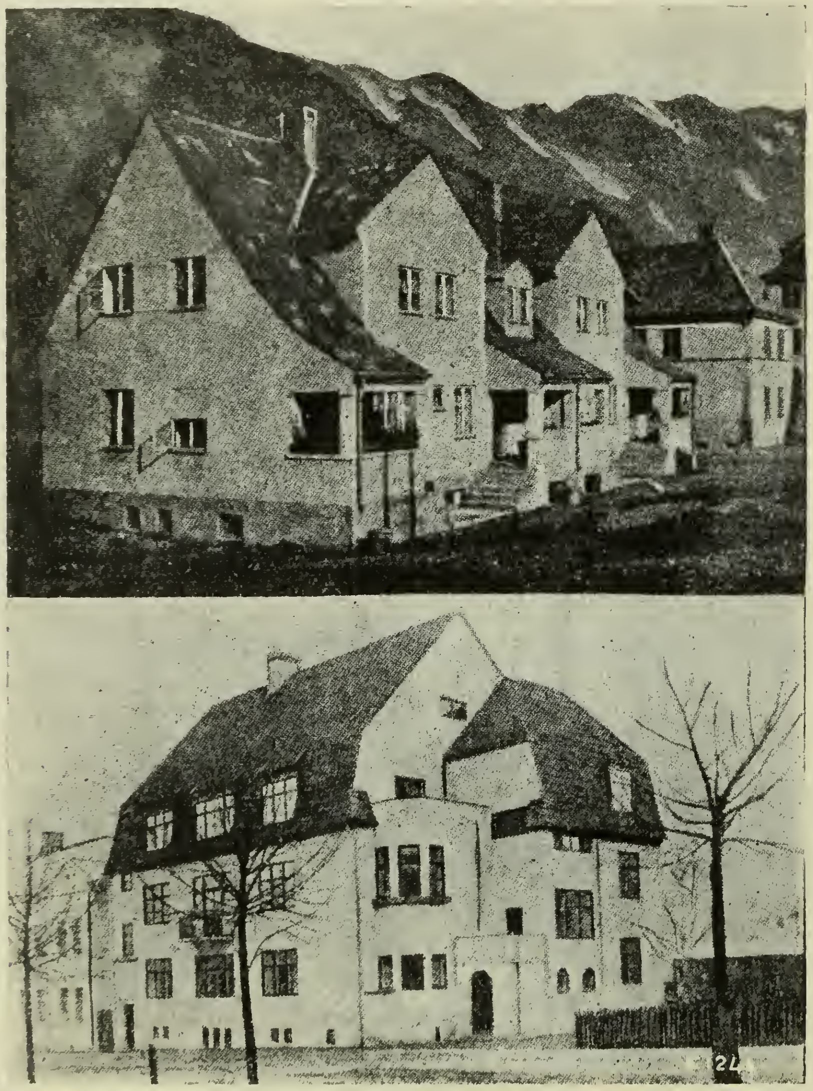
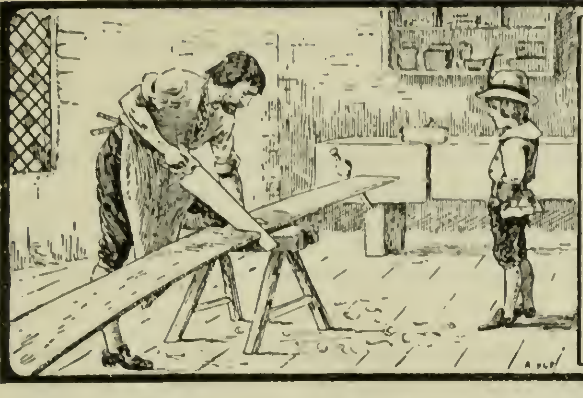


Fig. 4. The above show (*a*) some Workmen's Houses of Concrete in Norway, (*b*) a Large Single Residence in Stockholm, Sweden.

In America cinder concrete has been used, we understand, with good results. It is stated that this gives a light construction and sufficiently strong walls for considerable height and provides good insulation. The system is reported to have been used as far north as latitude 63, and has also been used in very warm climates in South America.

The Swedish Government has applied this system for a number of civil and military buildings.—*Concrete, U.S.A.*



SOME NOTES ON HOW TO FINISH A CONCRETE FLOOR.

Notes From a Practical Cement Finisher on Use of Screeds and Treatment of Aggregate and Surface.

For the following we are indebted to the "Engineering News-Record."—ED.

CONCRETE floor finishing is a trade and, like all trades, has its tricks. The difference between a good job and a bad one and between a profit to the contractor and a loss often lies in the way in which the practical finisher does his work. Some of the points which must be looked out for have been gathered here.

The setting of strips or screeds is very important. Care should be taken that they are set at a dead level and thoroughly blocked or braced underneath, so as to avoid sagging from the weight of the straightedge during the process of screeding. In nine cases out of ten they are set in an improper or haphazard manner, through carelessness or perhaps an ulterior motive. Where this happens, sagging is inevitable. The floor as finished is not level and depressions are formed, for the time perhaps not visible to a casual glance but later appearing with attendant costs. For instance, during the first trowelling the pressure of the float or trowel brings some water to the surface, which afterwards finds its way and trickles into the depressions, forming pools. By the time that these pools are very noticeable the finishers will have worked several yards away, and it would cause too much trouble or annoyance to remedy the defect, so it is passed over. Now, it takes hours in most cases—sometimes from six to ten hours, depending on the depth of the slab—before the water in those pools or pockets is thoroughly absorbed in the aggregate, and the result is that the finishers are obliged to "wait" before they can properly finish the floor, and, even then, they must work slowly over the depressions to avoid leaving "trowel marks," owing to the uneven surface.

DISADVANTAGE OF USING "DRYER."

Of course, the pools can be dried by an application of "dryer"—that is, a dry mixture of cement and sand or gravel, poured or laid in the depressions, to absorb the water. This is very often done, but necessitates walking over the fresh concrete, thereby causing other holes and disfigurements, which only retard the finishing, though the cost will be somewhat less than it would be if the finisher waits for the pools to dry out. In both cases overtime charges are common.

Where strips or screeds are properly set and are rigid, no depressions or pockets are left in the surface, and consequently the water in the aggregate is more evenly distributed, thus causing a uniform set. The finisher's trowel glides easily over the surface, " waiting " and extra work are eliminated, and the result is a great saving of time and money. Strips or screeds spaced about 12 ft. apart give the best results. The straightedge should be about 15 ft. in length, thus allowing an overlap at each end, and should be of a strong, rigid, light wood of 2-in. thickness, for on heavy screeding or " pulling " it often becomes tilted, and, if less than 2 in., will sag or bend from the strain of pulling, leaving the surface in a more or less rolling condition, which necessitates a second screeding and a consequent loss of time.

In " raw " finishing—that is, one-course work—the proper setting of screeds is, if anything, more important, as the screeding or levelling is heavy and laborious, depending on the aggregate. For instance, crushed rock 1¼ in. or less in diameter, with its attendant mixture of sand, etc., can be screeded faster and more easily than rock or other material of a larger size. In finishing a floor of this nature, it is usual and necessary to scatter or apply a layer of dryer over the whole floor to assure a " working surface," and this is usually done when the finishers are about to proceed with the first trowelling. This necessitates walking or laying boards over the fresh concrete in order to apply the dryer, causing depressions or holes in the surface. This is the wrong way ; the dryer should be mixed beforehand, and, as the screeding progresses, it should be immediately applied evenly to a depth of about ¼ in. In this way it acts threefold : (1) it begins at once to absorb the water on the surface ; (2) it eliminates subsequent walking over the fresh concrete, and (3) it saves time.

HOW TO TREAT SLAG AGGREGATE.

In " raw " finishing where slag is substituted for crushed rock or otherwise, it will result in a great saving of time if the slag is wet and thoroughly soaked for several hours before being mixed in the aggregate. It is a light material, and some particles are lighter than others, though of the same size. When the slag aggregate concrete is poured and screeded, if the slag is not wet down the lighter particles will persist in coming to the surface, where they will remain in spite of all efforts to submerge them, and the finishing becomes very tedious. When the finisher is floating and trowelling, those particles have the same effect as trying to float marbles into a hard floor ; they roll with the floating, scratching the surface, and very often have to be picked out by hand and cast aside. Again, the edges of the finishers' trowels are nicked and torn, and have to be filed or ground down, and considerable time is lost in the process. In trying to overcome all this, an extra heavy layer of dryer is required, although its success varies, in some cases requiring a second layer, thus consuming extra material and the time in mixing and laying it on the surface. Where slag is thoroughly wet and soaked before being placed in the aggregate, it absorbs a certain amount of water, thus gaining added weight, and is not so apt to appear on the surface, so it requires less dryer and less time in the process of finishing.

On floors previously left unfinished and which later require a top coat of cement mortar or wearing surface, either an acid or a cement wash is used, to assure the adherence of the mortar. Acid should be applied freely at least one hour in advance of the finish concrete pouring, but afterwards, and slightly in advance of this finish placing, the surface should be swept lightly to prevent an excess of water in the mortar. Cement wash should be applied only barely in advance. In pouring, the mortar should not be dumped or heaped at random about the floor, as usually happens, for in case of any excess of water this sets up a dam and creates " soft spots " which retard the finishing. It should be poured in a continuous mass, of an even consistency, somewhat in the nature of a thick paste, and raked always in the one direction. In this way " soft spots " are avoided and a uniform set is assured throughout.

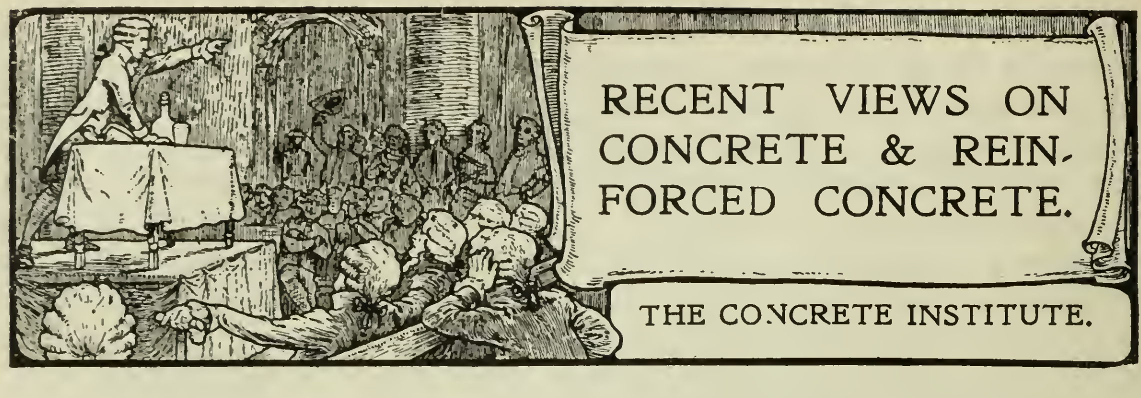
In floors where squares are required, considerable time is occupied in the jointing operation. The smaller the squares the more joints are required, and the more time is consumed. In marking out or spacing joints the ordinary way is to measure out and make notches around the edge of the floor, after the first trowelling. This is wrong, as it necessitates walking over the fresh material, and is a slow process. The economical way is to mark out chalk-marks on the walls or outside of the forms, before the material is poured, thus saving time and extra work.

The high cost of finishing cement or concrete floors can in many cases be attributed to negligence, or to a lack of knowledge on the part of those charged with responsibility. Every defect adds to the cost, and the right way is the economical way. To the causes shown in the foregoing others might be added, but all can be summed up in the words, " Faulty supervision."

MEMORANDUM.

A Hardener for Floor Surfaces.—A hardening solution for concrete floors that prevents dusting, says *Concrete* (U.S.A.), is made from sulphate of alumina and acidulated water. To 10 gallons of cold water (as soft as possible) add slowly 1 fluid ounce of commercial concentrated sulphuric acid. Heat the liquid to boiling-point and stir in gradually 25 lb. of commercial sulphate of alumina. When this solution has been effected let it cool and settle for several hours. Strain through muslin.

The concrete surface to be treated must first be swept and thoroughly washed. After drying, the hardener is put on, preferably with a broom. Four applications are recommended ; three consist of varying dilutions of the hardener with water, while the fourth is the hardener used 100 per cent. straight. These first three solutions are respectively : (1) 30 hardener to 70 water, (2) 50-50, and (3) 70 hardener to 30 water. Allow an interval of 24 hours between successive applications. The above quantity suffices for the complete treatment of an area of from 50 sq. yds. to 100 sq. yds., depending upon the porosity of the surface treated.



RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

THE CONCRETE INSTITUTE.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE DESIGN OF STEEL STRUCTURES.

By ALBERT S. SPENCER.

The following is a short abstract from a paper read at the eighty-seventh ordinary general meeting of the Concrete Institute. Mr. H. D. Searles-Wood, F.R.I.B.A. (President), was in the chair.

Introduction.—The design of steel structures is a task very often undertaken without a reasonably sufficient knowledge of the principles involved. A widespread distribution of pocket-books containing data and tables, provided primarily as time-savers, has enabled the recipients to utilise a limited knowledge of the theory of structures without, unfortunately, exercising a rational limit to its application ; and whilst there is in existence authoritative control over misdirected effort where such endangers human life, there is no such control—except in competitive designing—over the waste material and effort expended in the manufacture of structures the design of which is inefficient. Hence it is very advisable that purchasers should take every precaution to secure expert service to meet their needs, and to remember that what at first sight appears to be cheap may ultimately prove costly.

The principal object to be borne in mind by the structural designer—ignoring artistic and utilitarian requirements—is to evolve a structure which necessitates in its construction a minimum amount and cost of materials, the latter being distributed so that the structure will remain stable under the influence of the applied forces. This no doubt is a very elementary statement, yet nevertheless the saving that could be legitimately made in many designs by a more rigid attention to this fact, if a test be made, would amply repay the designer for his trouble. The economy is particularly marked where superfluous material is accumulated, as in the case of a multiple-storeyed building or in a bridge. In such a building any undue excess of material in the upper storeys has to be supported by the lower storeys, and ultimately by the foundations. In the case of a bridge the excess load acts as a force-moment, and where the span is only limited by the capacity of the constructive material this force-moment may have a serious effect in limiting the span.

The Theory of Structures.—The theory of structures embraces the application of mechanical principles to determine the stability and strength of structural units and of the units acting as a complete structure. These principles may be applied mathematically or graphically. The mathematical method is generally the simplest when the structure is rectangular in outline and when the external forces are normal to the exposed surface of the structure, whilst the graphical method is the simplest for structures having an angular exterior outline or when the external forces are angular to the structure. The principal points to be considered are :—

1. So to arrange the outlines of the structure as to reduce its resistance to wind pressure to a minimum and at the same time limit the force-moment of the wind.

2. The superimposed loads, or applied loads, should be kept down to the minimum consistent with safety.

3. To examine the structure as to its stability and to endeavour to eliminate any possibility of distortion or displacement.

4. To calculate the magnitude and nature of the stresses in the various units.

5. To determine the sizes of the units so that each will safely resist the greatest stress that can possibly be set up.

6. Where force-moments exist, to distribute the material in any unit so as to create the maximum economic resistance-moment, and also by introducing where possible such units as will enable the whole structure to have the maximum resistance-moment.

7. To take advantage of the variable unit resistance of the constructive materials.

8. To select such sections and materials as are readily obtainable and are economical in cost.

9. To arrange the members and the connections in such a way as to allow the direction and centre of action of the resistance force to coincide with that of the applied force.

External Forces.—The first step towards the achievement of efficiency in structural design—namely, to limit the external forces—can perhaps be best illustrated by a consideration of the outlines of a motor-car specifically designed for speed. The outlines of the car body will be such as to offer the minimum of resistance to wind force, or rather what is equivalent to wind force as regards effect, the result of which is to economise the power required to propel the car at any given speed.

A similar economy is obtained in a building (except that the saving is in the resistance necessary to maintain equilibrium and stability in lieu of power to propel) by the adoption of a low type of roof in preference to a high type—that is, by the use of a flat roof instead of a ridge roof, particularly if of large span. The economy is more apparent if it is realised that the extra wind force acting on the ridge roof has not only to be resisted by the framework of the roof itself, but also by the superstructure and the foundations.

Force-Moments. –Reverting to the example comparing a flat type roof with a ridge roof as regards the comparative resistance to wind force, the centre of action of the wind force acting on the flat type roof is much nearer the ground than is that for the ridge roof; consequently, whether or not the ground level is coincident with the fulcrum round which the wind force acts, the moment of the wind force is certain to be reduced thereby, and as a reduction in the external force-moment leads to a corresponding reduction in the required resistance-moment of the building, there is in consequence a saving in the material required to give the necessary stability. The popular designation of a structure in which the force-moment is high is that it is "top-heavy." The frequent use of this term, even by a layman, proves instinctive aversion to the uneconomic effect of excessive external force-moment.

Superimposed Loads.—The advisability of adopting a minimum safe allowance for superimposed loads is so apparent that on first thoughts it appears inadvisable to enlarge upon such a simple matter. Yet by a too rigid attitude in the use of conventional allowances, or perhaps more particularly as the result of compulsory adherence to bye-laws, we are often reluctantly compelled to misuse our constructive materials, and thus violate one of the principles of the theory of structures. Take, for example, a large departmental store in a small townshhip. The aggregate floor area may be such that the total load allowance for the human factor may considerably exceed the whole of the population, or, alternatively, the total number of people who can possibly be expected to assemble in the building; nevertheless, no relaxation is permitted. Of course, it is admitted that during the past few years some authorities have permitted a certain reduction of load on certain portions of a multiple-storeyed building; but this permission is based upon the fact that only a portion of the floors may be subjected simultaneously to the maximum load, and not to the anomaly referred to. Under the present restrictions, however, advantage may be gained by calculating all loads on the lean side rather than on the full side, a procedure always followed by competitive designers who wish to survive as such.

Stability.—Although there are many excellent treatises which deal with the theory of structures, too much attention is given to the application of the theory to the stability of structural units without sufficient consideration being given to the stability of the whole structure. A similar deficiency is noticeable in the treatment of this subject at our technical colleges. The result of this is discernible in present-day drawing-office practice, where many designers completely ignore the necessity for such stability calculations. There are many steel-framed buildings, and in fact buildings constructed of other materials, existent in this country which would not remain stable if exposed to the external forces which they are presumably expected to resist. Many units of a structure are habitually designed to resist a horizontal wind force of 40 lb. per sq. ft. and yet in the same structure units are permitted which would not resist one quarter of this amount, nor would the structure itself. The reason they remain stable is in all probability due to the over-estimation of the effect of wind pressure, and rather than have such inconsistency it is advisable to make a more conservative but consistent allowance. How many authors, for instance, deal with the design of foundations suitable for open sheds? Yet the stability of the shed depends upon its being provided with proper foundations. It is admittedly a difficult question to tackle, particularly to be able to square the result of applied theory with present practice, yet that is no reason why the question should not be rationally dealt with.

After dealing with the calculation of stresses, the determination of sections, resistance-moments, selection of sections and coincident forces the author went on to discuss the practical application of the theory of structures.

Practical Application of the Theory of Structures.—Of the two principal aspects of structural design—theoretical and practical—the latter has not been so well treated as the former, probably owing to the reason that literary ability is rarely attained by the practical designer until late on in life, by which time he is generally absorbed in the commercial side of the business and has no inclination to tackle the laborious task of placing his experience at the disposal of the younger generation. To anyone conversant with present drawing-office practice it is apparent that there is a wide gap in our system of technical education, since the majority of our young engineers obtain only a superficial knowledge of the vital principles of the theory and of its practical application. The primary reason is probably due to over-elaboration in mathematical reasoning. Mathematical reasoning is an abstract method, and the young engineer is too early presented with the problem of assimilating concurrently two lines of thought; and his struggles in the intricacies of mathematics obscure the important mechanical principles, a knowledge of which is really the end desired. The whole of the theory necessary to determine the stresses in structures which are statically determinate can be taught very simply, certainly much more simply than at present, and by this process the young engineer would be able to concentrate on the end desired, and his vision would not be so much concentrated on the means to the end. He would get such a grounding in first principles that he would never forget them.

Principles of Statics.—A full consideration of the fundamental principles of statics is beyond the possibilities of this paper, but attention may be directed to those which are most often misapplied. These may be enumerated as follows:—

1. Stress is proportional to strain within the elastic limit.
2. The modulus of elasticity is that force which would strain or deform a bar to a length equal to twice its original length, assuming stress proportional to strain without limit.
3. The distribution of bending stress is variable throughout the depth, and is a maximum at the extreme fibres.
4. The neutral axis is the plane of zero bending stress.
5. Horizontal shear force is the result of the increment of bending moment.

The points enumerated above were then dealt with in detail.

DISCUSSION.

Mr. M. E. Yeatman, M.A., M.Inst.C.E., in commenting on the paper, said that though a wind pressure of 40 lb. per square foot was quite possible over a small area, it was practically impossible over an area of, say, 1,000 ft.; therefore it was unnecessary to provide so much stress over a large structure.

Mr. E. Fiander Etchells, F.Phys.Soc., agreed with the author that a certain amount of authoritative control over misdirected efforts existed, but it was inadequate to stop all such efforts. In many cases those whose duty it was to look after the public safety incidentally cautioned designers sometimes that their designs were unduly extravagant for the purpose.

The author made a great point when he said that the extra wind force acting on the ridge roof had not only to be resisted by the framework of the roof, but by the superstructure and foundations If designers would bear that fact in mind there would be resultant economy.

With regard to the author's remarks concerning superimposed loads, Mr. Etchells said that in a small township it might be possible to get the whole population on one floor. Each floor must be capable of resisting the maximum total load; therefore the floors in a seven-storeyed building would have an aggregate bearing capacity seven times the weight of the population.

Mr. Etchells then referred to experiments carried out many years ago by Sir Benjamin Baker, which proved that the wind pressure over small areas was comparatively great, while that over larger areas was small.

Concerning the economic depth of joists, the addition of three inches to the depth of a joist might mean a corresponding addition of three inches to the height of the building, which in its turn might involve putting extra bricks round the building to keep the storeys at the same height as before.

Mr. S. Bylander said that the subject of standard beam sections was under review at present. He agreed with the author that the only basis upon which to decide a suitable standard list of sections was the factor of economy, and that of the thinnest possible web that could be easily rolled. No mention had been made of a suitable thickness to resist shear. There must be a proportion between thickness of the web and efficiency of the section ; further, a certain minimum thickness of metal was necessary to provide against corrosion. Too thin webs were not desirable owing to their tendency to bend during transport.

Mr. G. McLean Gibson said that it was well known to anyone in the habit of testing timber, especially for bending, that a timber beam always failed in compression, not in tension.

He condemned the too frequent use of flat bars in an end type of structure—for example, a bridge. The centre bays, if they got any variation of the load, were very often not stressed according to how the stress diagrams were taken out. Some time ago there came under his notice a roof which was normally carrying a load underneath, but due to a combination of circumstances the load was not applied. As the result of a heavy wind, some of the tension members, flat bars, buckled. Upon looking into the stress diagrams under different conditions, he found that there was a small amount of tension member ; owing to slightly different conditions, there was slight compression down a tension member. If that had been an angle it would have been all right, but as it was a flat bar it would not take it, and buckled. In conclusion, Mr. Gibson said it was always as well to have a little in hand with regard to the factor of safety. He mentioned a case where a floor, which was originally designed for 2½ cwt. per square foot, had carried 9 cwt. per square foot during two years of war before it gave way and then had to be remodelled.

THE LECTURER'S REPLY.

Mr. Spencer, replying to the discussion, said he wrote the paper for the benefit of the majority, not for the minority, as the result of his experience as a works engineer. With regard to the beam versus arch theories, he thought that, up to a certain point, they might be stated to be the same. He would separate the beam from the arch when there was very little bending stress—in other words, when there was horizontal shear.

With regard to floor loads, it was his frequent experience that buildings were put up where the provision for floor load was considerably heavier than it need be. It was to their pecuniary interest to design for heavy floor loads, but it seemed a pity to waste the material. He agreed with Mr. Etchells that the wind pressure on a small surface was much more than on a large surface. From a communication which he had had with the Bolton Corporation it appeared that 11 lb. was the maximum wind pressure recorded in Bolton for the nine years previous to his inquiry. At Greenwich Observatory the maximum gust velocity was 32 lb. per square foot, which would be equivalent to a steady pressure of 16 lb. He believed the equivalent pressure on a building was more like one-third of that given by an aerometer, and that 30 lb. or 40 lb. was too much allowance. He had taken 10 lb. to 14 lb. on the side, and 20 lb. to 30 lb. on the roof, and he knew that such a building had been better designed than those of his competitors.

Criticism had been passed on the narrowness of the joist flanges. The idea was to find the most economical joist as a beam ; then they could roll every section with the economical joist as a basis. The proportion of rolled steel joists receiving lateral support was nearer 90 per cent. than 50 per cent ; therefore they should design their economical joist irrespective of what lateral support it was to get.

Replying to Mr. Gibson, it was quite possible that the members in question buckled because of bad workmanship. Very often, if a triangulated frame were badly made, the members were slightly longer than they ought to be, with the result that the stresses were upset.

Mr. Gibson asked the author whether it was not unusual to find five cases alike out of eight girders. The girders were rivetted together on the ground, supported quite level right the way through, and after they had been rivetted up they were supported at the end, and it was only after they were hoisted in place that the trouble was found. Mr. Spencer replied that the stresses might be completely changed by bad construction.

CORRESPONDENCE.

Under this heading we invite correspondence.

Reinforced Concrete in the War Zone.

To the Editor of Concrete and Constructional Engineering.

Sir,—During my 3¼ years' service as a "Specialist Sanitary Officer" and, Commanding Officer overseas (nearly the whole of the time in the Active Area), I had many opportunities of inspecting reinforced concrete structures, such as elevated tanks, service reservoirs, retaining walls, buildings, bridges, and other structures (built in this material either by the enemy or by our own Engineers or the French), which had been damaged by shell fire, bombs, mines, etc., but I found no material to have withstood these shocks as reinforced concrete had done. I made a careful inspection of a large elevated tank on one occasion, erected above the ground about 30 ft., and supported by six reinforced concrete piers with bracings; a shell had caught the tank and laid it out full length on the ground; it was scarcely damaged apart from the piers having given way a few feet above the ground. This tank had been erected by French Engineers just previous to the war in connection with the water supply of Estaires; it adjoined the pumping station in that town, and was a very excellent structure.

I found no sign of corrosion in the steel bars when I removed the concrete covering from portions of the piers, and the aggregate was not the best either, there being too much limestone in it.

The behaviour of reinforced concrete generally in the War Area has considerably strengthened my confidence in the material, and, I would say that our own R.E. have left in France and Belgium some of the best work in this material that it has been my privilege to see.

E. R. Matthews,
Chadwick Professor of Municipal Engineering in the
University of London.

Concrete Along and Behind the Battle Lines.

[*The following is an interesting letter which appears in "Concrete" (U.S.A.), written by Captain Frank Whipperman, 53rd Pioneer Infantry, American Expeditionary Forces, showing how concrete was used behind the battle lines.*—Ed.]

Captain Whipperman writes as follows:

. . . On November 3rd I was severely gas poisoned—I awoke in a concrete block hospital ward, and when I was able to get out and walk about I found several hundred ward buildings in this hospital centre, built entirely of concrete block by the Army. These ward buildings were about 250 ft. long and about 24 ft. wide, with walls about 10 ft. to 12 ft. high. The floors were all concrete.

Naturally I was interested, and I nosed around until I found the plant where the block was made. I found a long, familiar looking shed, in one end of which a large concrete mixer was grinding out a semi-dry concrete mix of sand and cement, and down the centre of the building were a dozen or more hand-operated block machines of French make, with Chinamen, mostly, turning out block by thousands. The blocks were made and taken from the machines, which were of semi-stripper type, and placed on the racks to *dry*—similar to our old methods of making concrete products before we learned that to cure products is not to *dry* them. After several days' drying they were taken out and piled in the yard. The finished block are 12 in. long, 6 in. high and 6 in. wide, with four air spaces about 1½ in. by 3½ in.—a very compact and neat block, containing about one No. 4 shovelful of material.

Concrete Sewer Pipe.—Close by the block factory was a sewer pipe and tile factory, turning out 8 in., 10 in., and 12 in. sewer pipe in 3 ft. lengths. This pipe was being used everywhere by the Government for sewers. And I have noticed since in my travels about France that it is the only kind of pipe used here for sewers. The French use a great deal of concrete in all shapes and forms. Concrete block are used quite extensively in all kinds of construction work.

Stucco on Walls—Concrete Tile on Roofs.—Everywhere, especially on the better class houses, stucco of all colours and shades may be seen, while roofs are of concrete tile, in the manufacturing of which they use a red colour, which does not fade, and as most roofs have a growth of green moss the result is very picturesque—white stucco buildings with red and green roofs.

Floor Tile and Sanitary Ware of Concrete.—Kitchen sinks, lavatories, wash and laundry tubs are all of concrete. I have also seen many beautiful concrete tile floors and nearly all of the fireplaces in the newer chateaux are of ornamental concrete, and are very artistic.

Concrete Poles.— I have seen hundreds of concrete poles used in telephone, telegraph and electric transmission lines, miles of concrete railroad ties, and thousands of concrete fence posts. All the bomb-proofs, dug-outs, and pill-boxes were of concrete and concrete block, and withstood heavy shelling and bombing by aeroplanes.

Precast Timbers for Bomb-Proofs.—Much concrete was used in pre-cast timbers —beams 12 ft. long by 5 in. deep by 10 in. or 12 in. wide, reinforced with rods or angle bars. These beams were placed against buildings touching each other, at an angle of about 30 deg. They usually reached to a level just below the second storey windows, completely covering the first storey doors and windows and leaving a space about 6 ft. or 7 ft. outside of the building, which would be covered and serve the purpose of an *abri* or bomb-proof, and protect the lower part of the house against any serious damage from bomb explosions in the streets. It also provided a shelter for people caught on the street during an aeroplane raid.

Concrete Block in Trench Work.—Both the French and Germans used concrete blocks extensively in trench work, the Germans more extensively than the French. The Germans used concrete everywhere. The block used by them were about 12 in. to 16 in. long, 3 in. to 4 in. thick, and about 8 in. high. They were well made, and of a quite wet mixture, with graded material. They used them freely in walling up trenches and dug-outs and observation posts. Also back of the front lines they were used extensively in the Argonne sector for building barracks, etc. I have seen entire dug-outs of concrete built in places where they were continually exposed to the enemy fire. How they managed to build them, and to build them so well, without being observed, is something I cannot understand.

Old Concrete in South France.—While I saw some of the very newest concrete work, I also saw some very old concrete. I have a piece of concrete that I broke from the inner foundation of an old tower erected by the Roman Emperor Augustus, 7 years B.C. I have several pieces of concrete and mortars from old Roman ruins in the south of France—many centuries old. I put in a whole month sick-leave in the south of France, from the Italian border to Spain, visiting old Roman ruins, ancient cathedrals and other buildings. I walked up a circular winding stairs several hundred feet in a round tower of a very old church to an observation platform. These stairs were built of concrete over a hundred years ago, as near as I can find out. It was a marvellous piece of work, and entirely self-supporting, excepting the outside circle, which was built into the outside wall. The stairs showed no settlement or cracks, and I don't believe that so very much reinforcing was used in its construction. All the concrete work in France and Germany shows good workmanship and good design. . . .

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Reinforced Concrete Construction—Part I. By A. J. Cantell.

London: E. & F. N. Spon, Ltd., 57 Haymarket, S.W.1. 160 pp. + viii. Price 7/6 net.

Contents.—Advantages of Reinforced Concrete—Mixing and Depositing Concrete—Cement — Reinforcement —Bending Moments and Shear Stresses—Principles of Beam Design Single Reinforcement—Doubly Reinforced Beams — Slabs — Concrete and Tile Floors—Tie Beams and Floors—Main Beams—Shearing Reinforcements—Adhesive Stress—Inclined Stirrups — Columns — Long Columns — Eccentrically Loaded Columns — Formulæ — Areas — Tables.

This is the second edition of this volume, and it has been considerably revised as a result of the author's experience on the American continent, the revisions being such as to make the text comply as far as possible with American and Canadian practice in addition to British standards. As will be seen by the contents above, the book covers all the elementary principles of reinforced concrete work, and the reader will be able to obtain a good foundation for the study of more advanced problems in design. The text generally is well arranged and the formulæ are given, together with their derivation, in such a manner that an advanced knowledge of mathematics is not essential in order to follow the reasoning. This is the most important point in the preparation of any book intended for the student, but it is frequently overlooked by authors, with the result that the reader is soon lost in a maze of apparently meaningless symbols. The introduction of some notes on the design of concrete and tile floors is to be commended, as these are not usually found in text-books. The weakest feature of the volume is undoubtedly found in the illustrations, as these are not sufficiently clear and there is an absence of sizes and dimensions generally. It would have been helpful if the diagrams of the examples of shuttering had been figured up to show the typical sizes required in the formation of the different parts.

The chuting of concrete is described, but, as the author states, the method is not desirable when the compressive strength of the concrete is to be relied on to the limit. The book generally is to be recommended, and it should appeal to architects and students who have not made a serious study of reinforced concrete design, but who wish to commence at the very beginning.

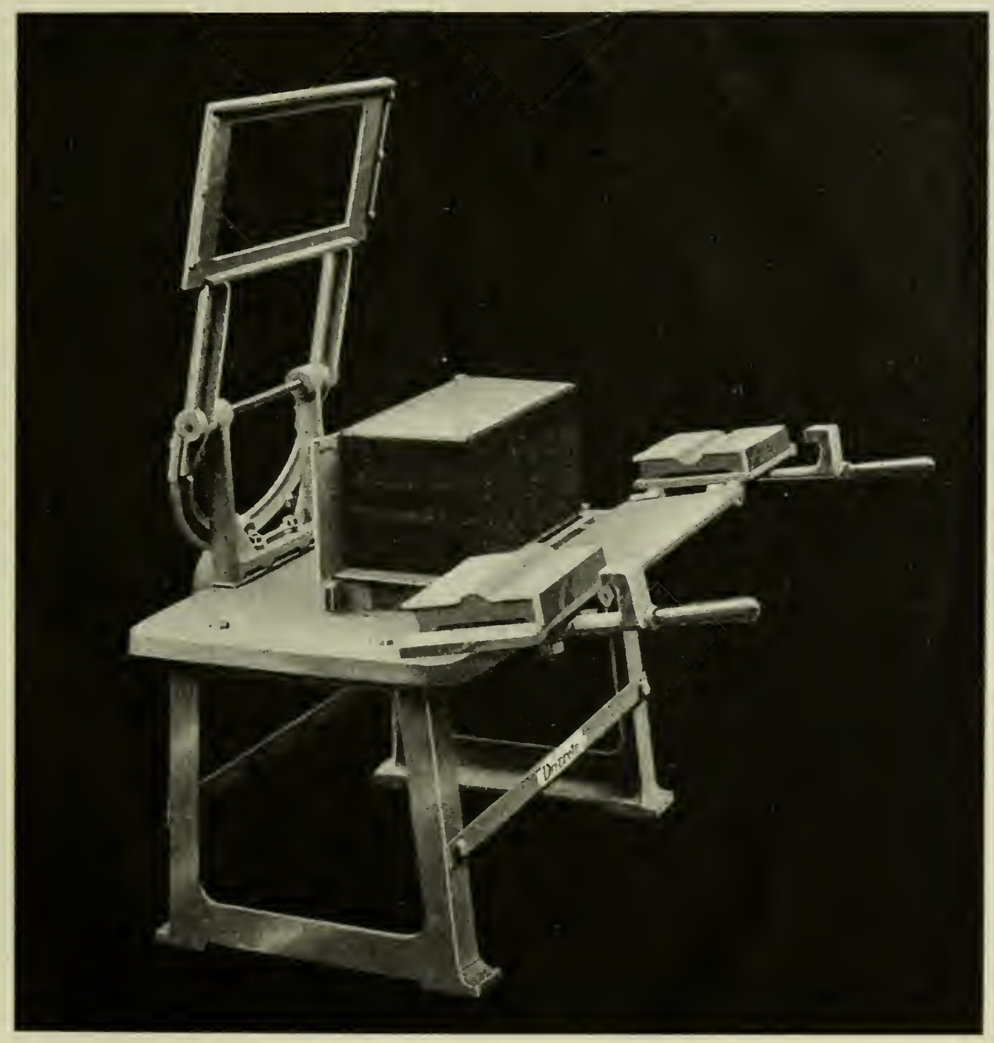
INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

A NEW CONCRETE BLOCK MACHINE KNOWN AS "DRI-CRETE."

Introduction.—The machine here illustrated has been devised by the inventor with the view of making solid concrete blocks which should be absolutely waterproof.

It is claimed that blocks made upon the "Dri-crete" machine will not only be waterproof but free from hair cracks and present more the appearance of stone with considerably harder faces.



Mixing.—The back of the blocks can be made of any of the usual concrete mixtures, but preference should be given to porous aggregates. The drawback to the use of concrete in humid atmospheres has often been the objectionable condensation. A porous concrete prevents the condensation which occurs on all non-absorbent surfaces. The use of a porous aggregate in concrete also makes the rooms warmer in winter, because the heat of the room is absorbed and held for several hours in the interstices of the porous concrete.

Another advantage of a breeze aggregate is, it gives easy fixing for mouldings, picture rails, skirtings and all internal fittings without the costly plugging which involves considerable labour and time.

The body of the block is gauged with 6 of aggregate to 1 of cement. The facing (which is applied in the second mould or frame) is a quarter of an inch in thickness and is composed of 3 parts of clean sharp sand (washed), 1 part of Portland cement, to which has been added 3 lb. of "Pudlo" waterproofing powder to every 100 lb. of cement.

With the "Dri-crete" method of making blocks the ordinary concrete is made considerably wetter, and the face being uppermost and finished off with the patent "Striker," it is claimed that it is possible to use a far wetter facing mixture than with any other method of making blocks.

Sizes.—Blocks made on this machine can be made in the following sizes:—18 in. by 9 in. by 9 in., 18 in. by 9 in. by 6 in., 18 in. by 9 in. by 4½ in., 18 in. by 9 in. by 3 in., 18 in. by 9 in. by 2½ in. and 18 in. by 9 in. by 2 in.

Labour-Saving.—As the blocks made upon the "Dri-crete" machine are made with a wetter mixture than on other machines, considerable labour is saved because the blocks only require watering the day after they are made instead of five or six days.

The "Dri-crete" machine also makes partition slabs either with or without a waterproofed face. To form the required thicknesses of the slabs, packing pieces are bolted to the bottom of mould box to raise the pallet to desired heights.

The standard "Dri-crete" machine makes blocks for ordinary walling 18 in. by 9 in. by 9 in., and also quoin or corner blocks of the same size. Extra fittings are supplied for making half and quarter blocks, which are multiples of the above sizes. Other attachments are made for producing blocks or slabs in the various thicknesses, and flue blocks, etc., can also be made.

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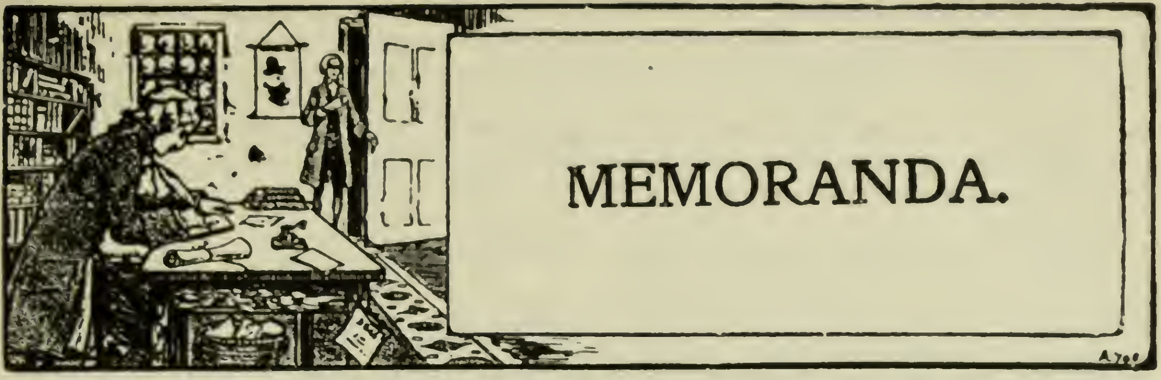


MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Short Course on Reinforced Concrete Design.—A short course on Reinforced Concrete Design, by Ernest Sprague, A.M.Inst. C.E., has been arranged for the Summer Term, and is now proceeding at the University of London, University College, Gower Street. The course consists of about 20 lectures, and may be extended to include drawing exercises. There will be three meetings a week. The fee for the course will be £1 11s. 6d. The course will meet on Tuesdays, Wednesdays and Thursdays at 10 a.m. Applications for admission should be addressed to Walter W. Seton, M.A., D.Litt., Secretary, University College, London (Gower Street, W.C.1).

An Inter-Allied Conference on Chemistry.—An inter-Allied conference on Chemistry will be held in London from July 15th to 18th, at which the following countries will be represented: Belgium, the United States, France, United Kingdom and Italy.

A previous conference took place in Paris during the month of April, when various questions of importance to the chemical industry were discussed.

British Industries Fair, Birmingham.—This Fair is to be held concurrently with the British Industries Fair in London and Glasgow, February 23rd to March 6th, 1920. under the auspices and support of the Board of Trade and the joint organisation of the Birmingham Municipality and Chamber of Commerce. All desiring to exhibit should apply for full particulars to the General Manager, Chamber of Commerce, 95, New Street, Birmingham.

Housing and Health Exhibition, Glasgow.—An exhibition dealing with the housing question is to take place in the Kelvin Hall, Glasgow, October 8th to 25th. The exhibits will include building materials, furnishings, lightings, heating and cleaning appliances, sanitary appliances, decorations, etc. Lectures will be given on all subjects applicable to the aims of the Exhibition. For particulars as to space, etc., apply to James N. Freer, Kelvin Hall, Glasgow.

Industrial Problems.—We desire to draw the attention of our readers to a summer school which is to be held under the general direction of Lieut.-Col. C. J. Myers, Sc.Dr. F.R.S., at Cambridge during the month of July. The school should be of special practical value to those interested and concerned in industrial management. Two distinct courses will be held, each of a week's duration: (1) July 13th to July 19th inclusive: (2) July 20th to July 26th inclusive.

Among the subjects announced for lectures and discussions are the following: Industrial Psychology (Vocational Selection, etc.), Industrial Fatigue and Neurasthenia, Time and Motion Study, Social Psychology, Ethics and Industry, Education in Relation to Industry, Welfare Work, Scientific Management, Industrial and Business Organisation, Salesmanship and Advertising, Modern Labour Movements (Guild Socialism, Syndicalism, etc.), Industrial Research.

There will also be practical work at the Psychological Laboratory. The lectures will be given at the Psychological Laboratory, the library of which will be available for members of the school.

For full particulars regarding fees, accommodation, etc., apply to the Organising Secretary, Industrial Problems School, Psychological Laboratory, Cambridge.

Industrial Administration.—We also beg to call the attention of all those concerned with the management of industrial enterprises to a special series of lectures to be given by Mr. Elbourne (Messrs. Brindley & Elbourne) on Industrial Administration. The lectures will deal in a practical way with present day reconstruction problems within the factory. They will take place during June and July. The object of the lectures is to promote industrial efficiency by focussing attention on the underlying principles.

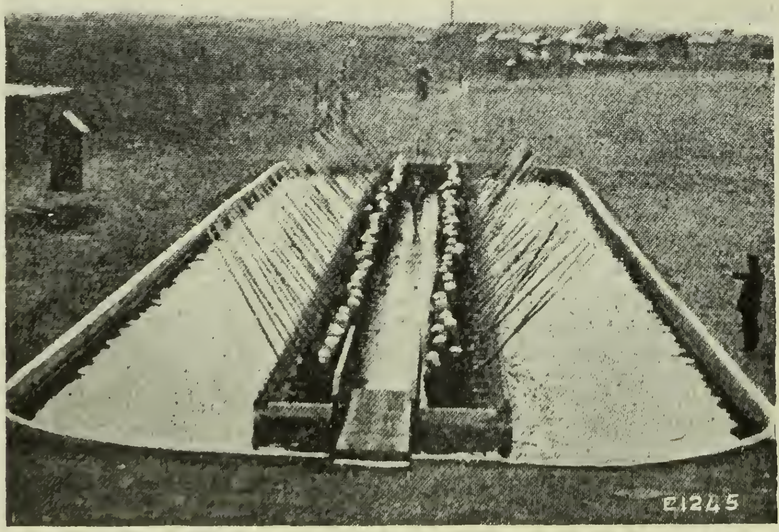
For full particulars apply to Messrs. Brindley & Elbourne, 110, Victoria Street, S.W.1.

Wood and Rushes as Reinforcement.—The use of wood instead of steelfor reinforcing concrete has long been known, but it has been found more recently that wood is inferior to rushes, as the latter do not readily perish.

Rudolf Grimm, of Vienna, has erected a number of single storey buildings in which the reinforcement consists of a hollow framework of wood, around which was placed the concrete. The wood was impregnated with magnesium chloride previous to being used.

When wood is used as a reinforcing material, it should be impregnated in this manner, and the wood must be so placed that any change in the cross-sectional area does not affect the durability of the structure. If the latter precaution is overlooked the concrete may crack. Small strips of wood are better than larger ones, and rushes appear to be excellent for the purpose, especially for thin walled structures such as ships. K. W. Ljungdell has been granted a patent for a combination of wood and rushes as reinforcement, the use of metal being limited to a few ties and hooks.—*Beton u Eison*, 1919.

Rowing Machine of Concrete.—A rowing machine of concrete has been built at the Cape May, N.J., Naval Training Station. It is built in a large pond, which permits the free swing of the oars. The rowing machine is for the purpose of training men how to handle the oars properly and manage a small boat. The illustration shows the machine with every man in place.—*Concrete*, U.S.A.



A CONCRETE ROWING MACHINE.

Concrete for Farm Buildings in Switzerland.—In some new farm buildings recently completed at Saligny, near Geneva, hollow cement blocks were used for the walls and the first floor is of reinforced concrete.

Concrete Earth Dam.—The shortage of steel rods and bar, as well as of expanded iron, for use in reinforced concrete work during the war led to the adoption of some curious substitutes, amongst which may be mentioned rods of some wood, such as lancewood or birch, which possessed a good power of resistance to tensile strains. It was essential for many reasons that the huge reservoir planned by the Empire Pipe Company at Cainesville should be completed without delay, but as it was impossible to get steel or iron girders for reinforcing, the idea of constructing the dam in the ordinary manner by using reinforced concrete had to be abandoned.

A novel method of construction was adopted, which has been copied extensively in the United States. An earthen embankment 12 ft. wide and 22 ft. in height was built to form the wall of the tank, and the slope was such that the tank was 392 ft. in diameter at the top and 326 ft. in diameter at the bottom. It will be seen from this that the slope of the sides is very abrupt, being actually 392 less 326, equals 66, divide by 2 equals 33 ft. per side in 22 ft. depth, equals 1 in 1½. The inside and the floor of the tank are covered with a lining of fine concrete, 3½ in. in thickness, which serves as a practically unbreakable shell supported by the rammed earth beneath. A lid for this huge tank is built of concrete slabs, 2½ in. in thickness, and supported on timber joists and girders, carried on uprights. When the work was completed, it was found that the total costs of this method of construction had worked out at about 1s. 4d. per barrel of capacity.

A Concrete Grain Silo.—A silo to hold 4,000 tons of grain, together with the necessary cleaning machines erected in 1916 in Muhldorf, Bavaria, contains several unusual features. The grain is discharged from the railway trucks into hoppers, and is conveyed by an elevator to the top of the structure, where it is carried by a conveyor to the various cells. From the cells the grain falls through pipes into screw-conveyors to another elevator, which raises it to the top of the building if it is to be placed in another cell, and to the third story if it is to be treated mechanically. The side walls of the cells are provided with numerous vertical cavities with slits which serve to ventilate the cells to different depths, so as to ensure efficient ventilation for the whole of the contents. The hollow walls necessitated a special arrangement of the supporting members on walls instead of distributing their weight on pillars placed uniformly apart.

The roof was constructed of hollow blocks. Special care was taken to ensure the structure having ample strength to resist the stresses of the various conveyors and elevators. The work was commenced in November, 1916, and was completed in time for the 1917 harvest. The hollow walls are found to have excellent heat-insulating properties, as well as serving good ventilation. The whole arrangement is extremely simple, and has proved to be very effective.—*Beton u Eison*, 1919.

Effects of Colours on Tensile Strength of Cement.—In order to determine the effect of various commercial colours used in Concrete work upon the tensile strength of Portland cement, the following series of tests were made in America by Mr. O. R. Smith, testing engineer, Canonsburg, Pa.

Usual cement testing procedure was followed in all the tests, the test pieces being aged in water. Ten per cent. of the colour was used in each case, except the black, of which only 5 per cent. was used.

The results—in each case the average of three tests—are given in the following table :—

Age.	No Addition	Brown. 10 %	Red. 10 %	Black. 5 %	Yellow. 10 %	Buff. 10 %
24 hours neat	400	370	373	290	375	385
7 days ,, ...	710	670	640	690	645	610
28 days ,, ...	785	830	710	640	750	760
3 months ,, ...	800	910	875	785	840	830
1 year ,, ...	890	890	810	800	790	800
7 days ⅓rd sand ..	300	340	310	240	300	320
28 days ,, ...	360	360	380	320	420	470
3 months ,, ...	490	410	520	360	475	400
1 year ,, ...	445	445	420	410	400	440

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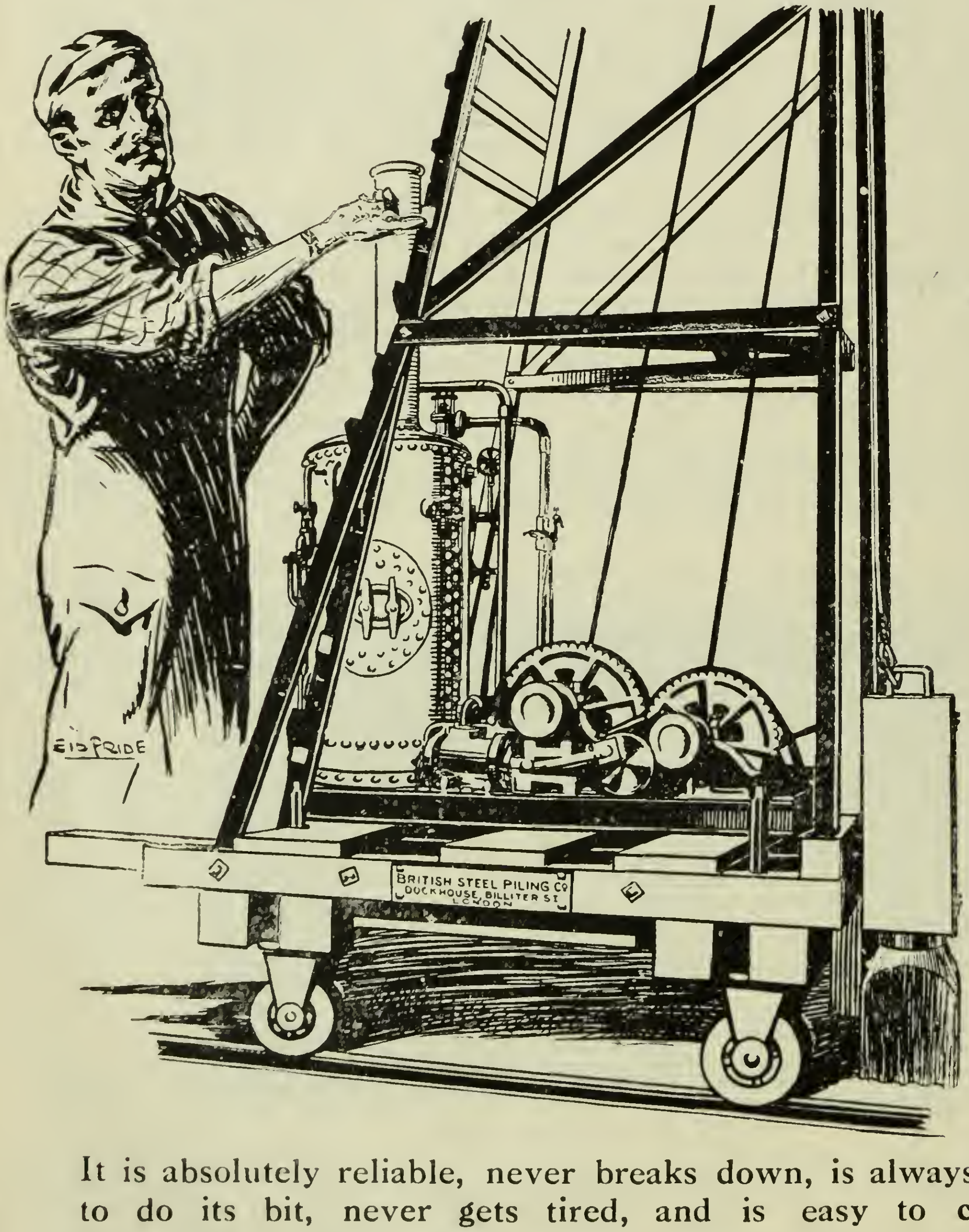

A WORKMAN'S OPINION.

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A Reinforced Concrete Factory.—The contract has been awarded for the construction of a reinforced concrete factory 210 ft. by 80 ft., five storeys high, for the Adams & Beeman Chewing Gum Co., to Messrs. F. D. Huntington, Ltd., 11, Hanover Square, W.1.

Bridge Across the Mississippi.—The proposed bridge across the Mississippi River at Minneapolis will have the longest reinforced concrete arch in the world. The present longest is the Risorgimento Bridge at Rome, 328 ft. long. The Minneapolis bridge will have a centre span of 400 ft., two side spans of 200 ft., and two end spans of 60 ft.

Reinforced Concrete Water Mains.—The Birmingham Water Committee have prepared a scheme for the construction of sections of a third pipe on the syphon sections of the aqueduct from the Elan Valley to Frankley, and for strengthening the existing mains, involving an estimated total expenditure of about £500,000. In June, 1917, the committee reported that, in view of the liability to bursts to which cast-iron mains had proved subject, they had made enquiries respecting reinforced concrete, and the idea had been suggested that as pipes of that material were not subject to the same limitations of diameter as those of cast iron, it was worth examination whether the provision of a main of double capacity might not be economically advantageous. The arguments in favour of pipes of this character over those of cast iron and steel, briefly stated, are :—

(*a*) The initial cost would probably be less.

(*b*) The liability to bursts is evidently very much less than with cast iron. No case of failure upon mains in reinforced concrete is recorded in the places where such have been laid.

(*c*) The absence of liability to corrosion, thus giving a lengthened "life" to the main.

(*d*) The possibility of constructing pipes of much greater diameter, compared with cast iron. This is a very important consideration, as the Water Committee consider it wise to provide a main having the capacity of two mains of the diameter (42 in.) of the existing mains, thus providing double capacity at a much less proportionate increase in cost.

When the proposal for a main of double capacity was first brought forward, the principal drawback was that it would be necessary to lay the double-capacity main over the whole length of the syphons, involving a total strength of about 37 miles before any augmentation of the supply could be secured. This difficulty has now been overcome by means of cross-overs designed by Mr. F. W. Macaulay, the Elan Supply engineer, by which the new main can be carried out by instalments, sections being laid and brought into use as they are completed without waiting for the construction of the main throughout, the supply being augmented immediately in proportion to the sections of main laid.

An account of the experiments on which the engineer arrived at his conclusions was placed before the Local Government Board, who advised that the principle appeared to be sound, and suggested that the committee should proceed with the preparation of the plans. On receiving this notification the committee instructed the engineer to prepare a scheme for the provision of such lengths of main as would be required for the passing of an additional 4,000,000 gallons per day through the Severn and other syphons, the mains to be of double the capacity of the present mains. The engineer advised and the committee approved of the laying of the sections of the new main in reinforced concrete on the "Bonna" system, the diameter to be 60 in., which is calculated when completed to provide a discharging capacity double that of each of the existing mains of 42 in. diameter. The "Bonna" system, which has been extensively used on the Continent, consists of a steel tube which gives water-tightness, is lined inside and out with concrete, embedded in which are longitudinal strips, wound round with a steel bar giving the required strength. The total length of the double-capacity main proposed to be laid is 9·17 miles, but no lengths of new mains are required on the other syphons, which have a total length of 4·03 miles. The estimated cost of the work is £500,000.

PERSONAL.

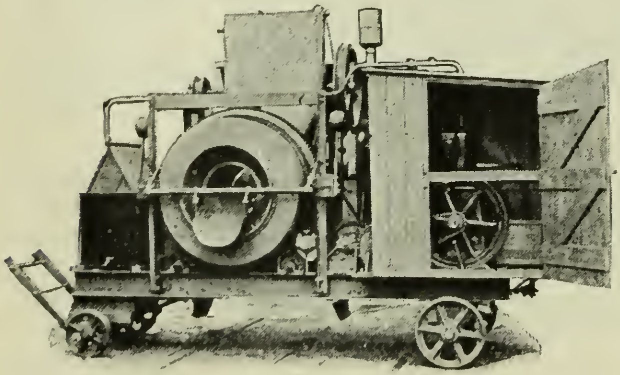
Our readers will be interested to hear that Major G. S. Heathcote, M.V.O., who has been on military service in France ever since the commencement of the war—who in pre-war days was a director of and the chief engineer to The British Reinforced Concrete Eng. Co., Ltd.—has now severed his connection with that firm, and is now engaged upon reconstructional work throughout France and Belgium, with special reference to the devastated areas. His company, "Constructions Rapides," head office, 34, Rue Labruyère, Paris, are taking up agencies for British firms manufacturing building and factory specialities. They are opening sub-offices in Amiens and Brussels. Major Heathcote informs us that he would welcome correspondence from firms wishing to do business.

TRADE NOTES.

Freezing Plant.—"Freezing plant has been erected on such a gigantic scale in Australia that a reservoir containing one million gallons has been constructed to supply the Government refrigerators in Western Australia. The reservoir was built of waterproofed concrete which stood all the tests, the executive engineer expressing his satisfaction with the economy resulting from the use of the powder 'Pudlo,' the medium employed for waterproofing."

Rogg Concrete Paint.—The attention of our readers is called to this paint, which is suitable for application to concrete and cement surfaces. The makers explain that the essential difference between this paint and an ordinary oil paint lies in the fact that it is free from linseed oil, which with alkali together produces a soap. The oil used here does not dry, as does linseed oil by oxidisation, but by a process known as polymerisation, by which the whole character of the oil is changed and the product rendered absolutely unsaponifiable. Rogg Cement Paint is made in all colours and should be obtained in the shade or tint required, as ordinary stainers or driers in oil cannot be added without injury to the paint.

For full particulars and prices apply to Messrs. Dixon's White, Ltd., Paint Works, Albion Wharf, Bow, E.3.



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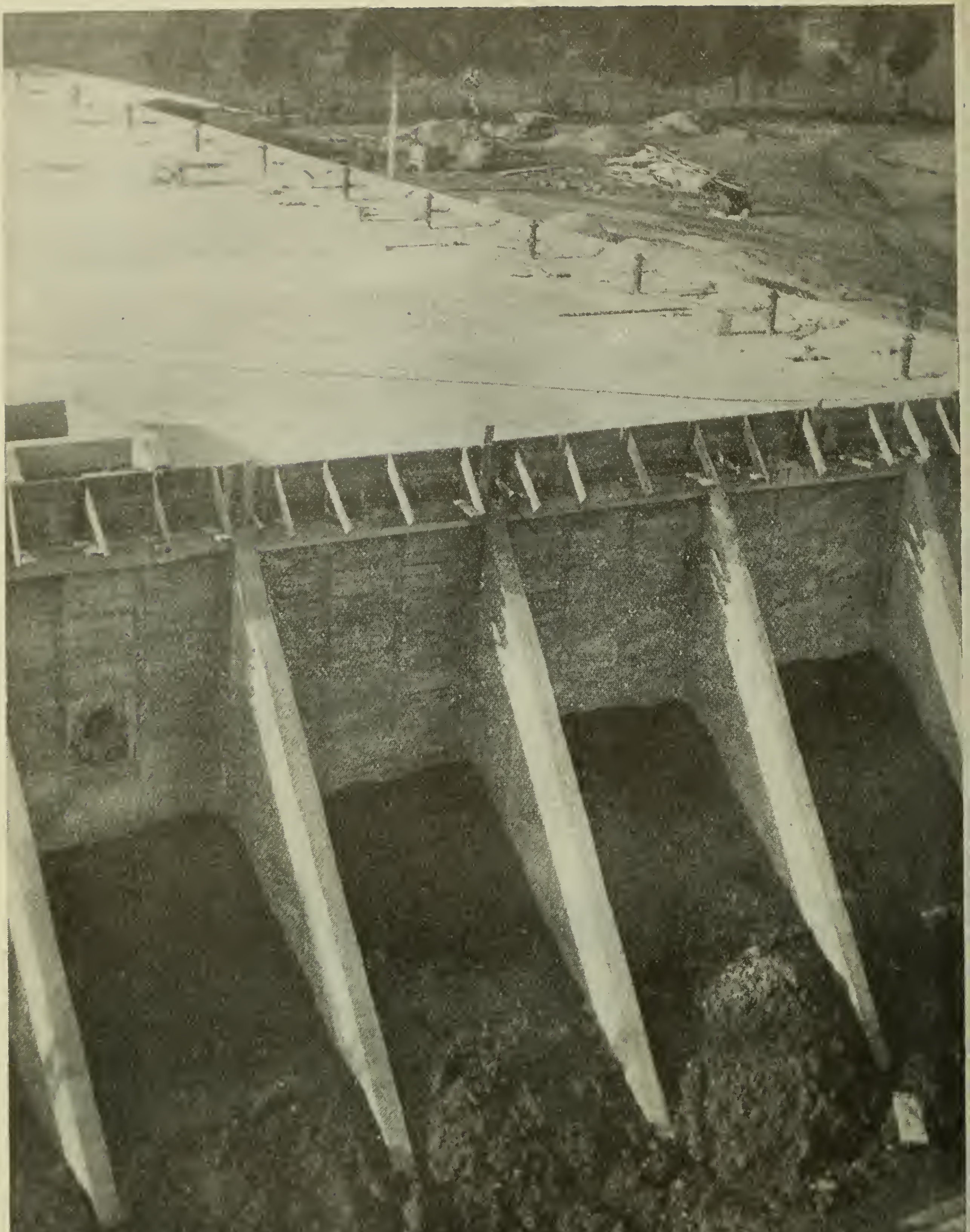

Reinforced Concrete Reservoirs at Montevideo.

(For description see page 337.)

pp. 41– Bound between June + July Iss. pp. 232 + 233

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

"CONCRETE SHIPBUILDING"

A Monthly Supplement

Issued Free to Subscribers JANUARY, 1919 *Single Copies 1/-*

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

The present supplement is the third of a series of supplements we propose to publish giving a general review on the subject of concrete shipbuilding. In addition we hope in each number to include illustrations and particulars regarding current activities in this particular, as far as we are able to obtain and publish such information. It is hoped that these supplements will prove of use and interest to all those who are engaged in one branch or another of this particular form of the shipbuilding industry. We are indebted to the courtesy of Messrs. Cassell & Co. for many of the blocks appearing in the current Supplement.—ED.

CHAPTER III.

THE MATERIALS USED IN CONCRETE VESSELS.

THE materials used in the construction of reinforced concrete vessels are readily arranged in two groups—namely, the *concrete* and the *reinforcement*. If the former is compared to the flesh, the latter is comparable to the bones of the animal organism, giving it a rigidity combined with a resiliency where elasticity is required and a resistance to shocks which cannot be obtained when no " skeleton " is present. Concrete without reinforcement has an enormous resistance to crushing, but it is relatively weak when subject to tensional or bending forces. The reinforcing material, on the contrary, is chosen on account of its great resistance to tension and bending, and the combination—known as reinforced concrete—is one of the strongest as well as one of the most durable constructional materials known.

REINFORCEMENT.

The reinforcement almost invariably consists of a network of mild steel—either in the form of rods, bars or flat strips fastened together by wires or by welding, and strengthened, if necessary, by the use of angle-irons, T-bars, etc., to form ribs and beams of great tensional strength. Alternatively, a combination of strong bars with the intervening spaces occupied by wire netting or expanded metal is sometimes used. The chief objections to the use of this method of reinforcement in large sea-going vessels are the difficulty of varying the network to suit the different stresses, the difficulty experienced in keeping it in place, and its high cost. None of these is insuperable, and several entirely satisfactory vessels of moderate size are reinforced in this manner.

The use of tubes screwed together so as to form a reinforcing framework was patented by E. Molloy (U.S. Pat. 808,467), but no use appears to have been made of this invention.

When bars are used as the reinforcing agents, they are generally of plain circular cross section, but bars of special shapes are sometimes used and are considered to exert a greater grip on the concrete. Bars of various shapes and sizes may be used in combination in order that the desired resistance to tension and shearing may be secured. The reinforcing bars are usually made of mild steel with an ultimate strength of from 28 tons to 32 tons per sq. in., an elastic limit varying from 30,000 to 40,000 lb. per sq. in.,* and an elongation of at least 20 per cent. on a length of eight times the diameter. Such steel was used in the construction of most of the numerous river and canal barges and pontoons built in reinforced concrete during the last fifteen years, and it was natural to look to the same material again when great impetus was given lately to the construction of seacraft in reinforced concrete. Shell-discard steel has been suggested as a substitute, but for the present, apparently, Lloyd's Register are not prepared to sanction its use.

The coefficients of expansion of steel and concrete are almost identical at ordinary temperatures, otherwise serious internal strains would be produced. The actual coefficients of expansion vary with different specimens, but on an average steel expands 0·00065 per cent., and the concrete 0·00060 per cent., for a rise in temperature in each of one degree Fahrenheit.

Steel with a high percentage of carbon is unsuitable for use in reinforced concrete, as it is brittle (particularly after hammering), is more costly and more difficult to work than mild steel. Steel containing less than 0·3 per cent. of carbon is not open to this objection, and consequently mild steel is almost invariably used.

The Committee of the Concrete Institute recommend that the steel used shall have the following properties :—

(*a*) It shall attain an ultimate tensile strength of not less than 60,000 lb. per sq. in.

(*b*) It shall withstand a stress of at least 34,000 lb. per sq. in. before showing any appreciable permanent set.

(*c*) The contraction of area at fracture shall be not less than 45 per cent., or the elongation in the case of bars of 1-in. diameter and under shall be not less than 25 per cent., measured on a length equal to eight times the diameter of the bar tested.

The elongation shall be measured in the case of bars over 1 in. diameter on a length equal to four diameters of the bar, and shall not be less than 30 per cent.

(*d*) All steel shall stand bending cold to an angle of 180° around a diameter equal to that of the piece tested, without fracturing the skin of the bent portion.

(*e*) The steel shall be free from scabs and flaws, and must be clean and free from rust. It must not be painted or oiled, but a wash of Portland cement grout is desirable.

The Joint Committee, under the auspices of the Royal Institute of British Architects, has made very similar recommendations, but in (*b*) this committee places the elastic limit at not less than 10 per cent. nor more than 60 per cent. of the ultimate strength, and the minimum elongation (*c*) at 22 per cent., and requires the steel to stand the other tests specified in the British Standard Specification for Structural Steel.

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* A minimum of 50,000 lb. per sq. in. is preferable in shipbuilding.

Welding as a means of fixing bars in position is to be avoided wherever possible ; if necessary, it should be at the points of minimum stress.

Some of the firms specialising in concrete construction have even stricter conditions in their specifications. The following extracts from specifications issued by several leading firms give some idea of these *additional* requirements :—

British Reinforced Concrete Engineering Co., Ltd.—All rods, plates, bars or braces to be of mild steel, manufactured on open-hearth basic or acid Siemens process, uniform in quality, and entirely free from defects.

Ultimate tensile strength not to be less than 28 nor more than 32 tons per sq. in.

All steel on delivery to be cleaned and stored in a dry place.

All stirrups and hoops to accurately fit the rods and bars, and to be bent to proper shape.

Trussed Concrete Steel Co., Ltd. (*Kahn System*).—No reinforcing steel shall be considered that does not provide for shearing stresses as well as direct tension.

These shear-resisting members must be inclined at an angle of 45°, pointing up and towards the supports of the structure.

Shear members shall be rigidly attached to main tension members.

Sufficient steel to be placed that concrete shall be obliged to resist only direct compression and shearing stresses up to 50 lb. per sq. in.

No steel shall have at any point less than 1 in. concrete covering.

In no case will steel of a higher elastic limit than 45,000 lb. be considered. The same shall have a tensile strength of from 60,000 to 70,000 lb. per sq. in., with elongation not less than 20 per cent. in 8 in.

British Concrete-Steel Company.—The indented steel bars to be of best quality ; tensile strength, 38 to 42 tons per sq. in. The elastic limit must not be less than 50,000 lb. (22 tons) per sq. in.

Ample supply of soft iron wire is to be provided for lapping steel bars at the joints, and at points where they cross each other.

L. G. Mouchel and Partners (*Hennebique System*).—The steel to be in the form of round bars and strip, obtained from makers of good repute, and to be mild steel produced by the open-hearth, basic or acid process. Neither Bessemer steel nor high-carbon steel to be employed.

Considère Construction Co., Ltd.—The steel must be of British manufacture and have a tensile strength of not less than 28 tons or more than 32 tons per sq. in., and must show contraction of area at fracture of 50 per cent. and 40 per cent. respectively, and the appearance of fracture not to show more than 5 per cent.

Expanded Metal Co., Ltd.—The mixture of concrete is not to be less than 1 : 2 : 4 by volume. Working stress should not exceed 16,000 lb. per sq. in. by tensions in the expanded steel, and 500 lb. per sq. in. extreme surface compression in the concrete. The ratio of the moduli of elasticity of steel and concrete to be taken as 15.

Edmond Coignet, Ltd.—The annealed wire used for binding together various bars of framework at intersection should be about $\frac{1}{16}$-in. diameter.

The binding to be done as tightly as possible, and cutting pliers used.

As a further precaution against the action of salts in the sea or canal water in which the vessel floats, the reinforcement may be galvanised or protected by a coating of a suitable paint. If the concrete is properly made, however, and is quite impervious to water, such treatment appears to be unnecessary.

The rods for reinforcement should be ordered to the exact lengths required so as to avoid scrap and waste. The $\frac{3}{16}$-in. and $\frac{1}{4}$-in. rods, as well as the larger ones, should be purchased in straight lengths and bundles ; sometimes they are purchased in rolls, and then require to be straightened with a hand machine. If they are badly bent they should be warmed and straightened, but if bending is required it should be done cold. It does not matter if the rods are rusty in appearance, but they must be free from paint, grease, loose rust, dirt, or other foreign matter.

Owing to the necessity of reducing the weight of the hull to a minimum, it is essential to make full use of the steel reinforcement and to use a material of a high elastic limit, this limit being a very important factor in all reinforced concrete work. A simple means of doing this is to use bars with a rough instead of a smooth surface, and particularly those which subsequent to being rolled have been stressed by twisting them in such a manner that the elastic limit is raised about 35 per cent., the twist in the bar giving it an additional hold on the concrete. Such bars are known as special bond bars. In indented bars, a similar effect is produced in a different manner by means of a series of depressions in the bar. The object in using such shaped bars instead of plain ones is to obtain a continuous mechanical bond with the concrete in which it is embedded. With this, small sections and a shorter overlapping of the bars at junctions may be employed than would be possible with an ordinary plain bar, and it also facilitates a reduction in the weight of steel used. A further advantage of indented or twisted bars lies in the fact that steel of lower tensile strength may be used, and so release the higher quality steel for other important work.

The use of bars with a mechanical bond, and consequently a grip on the concrete which is 50 to 60 per cent. greater than that of plain bars, not only enables thinner and therefore lighter bars to be employed, but by providing more space in concrete of a given thickness it reduces the risk of the bars slipping.

In reinforced concrete construction, the bars, etc., are only fastened sufficiently to hold them in place until the concrete has hardened ; they are seldom welded or riveted together, but are tied with thin wire, or are interlaced with each other. When the concrete is in use, any stresses to which the mass is subjected are transmitted from bar to bar through the agency of the adhesion or grip of the concrete surrounding them, the bars overlapping each other. Their ends are usually fish-tailed or hooked, with a view to helping the adhesion. In ordinary reinforced concrete work on land, the mass of concrete surrounding the rods is comparatively large, and there is ample room for overlapping of the rods and for the hooks of fish-tails, and it is not essential to use bars with a mechanical bond. In ship construction, on the contrary, the bars are very much closer together, and with plain bars difficulty is experienced in finding room for overlaps of the length required, and also for hooks, especially in longitudinal members. Experiments carried out in France in 1917 upon a river barge of 400 tons deadweight, which was purposely tested until rupture under load in the dry, proved the ultimate failure to be due to the slipping of the plain longitudinal rods, consequent upon the insufficiency of overlapping, and showed the advisability of using at least a proportion of bars having a mechanical bond. Such a bond must not be secured by the use of sharp projections or ribs on the bars which might have a tendency to be the starting point of minute cracks in the concrete, and which, in addition, are useless from the point of view of the main stresses. In other words, the bond should be continuous, and should not entail an additional weight of steel. A. A. H. Scott insists that every bar used in reinforced concrete should have hooked ends, the radius of the hook not being less than five times the diameter of the bar. He considers that bars with fish-tailed or split ends should not be used.

The steel must be sufficiently ductile to be bent, whilst cold, around a cylinder 1½ times the diameter of the bar without any injury. No brittle bars should be used.

The sizes of the various bars must depend on the stresses to which it is anticipated they will be subjected, and this also determines their position relative to each other.

It must suffice here to state that the larger steel bars are arranged longitudinally, generally in way of the deck line and the bottom of the ship, rods of nearly the same size being arranged transversely, and the whole being connected by small bars from $\frac{3}{16}$-in. to $\frac{1}{4}$-in. diameter, forming, say, a 6-in. mesh over the whole surface, and making, as far as possible, a monolithic structure. A reduction in the number or total sectional area of the rods, both longitudinally and transversely, is arranged towards the ends of the vessel, where the bending moment is less.

There are four methods of joining the steel rods: (1) By a long overlap which is usually forty diameters of the rod, although some go as low as twenty diameters, and relies entirely upon the adhesion or grip of the concrete to the bar; (2) by a short overlap of, say, twelve diameters in the small rods and eighteen diameters in the rods over 1-in. diameter, which relies mostly upon the hooked ends of the bars and appears to be a satisfactory solution, as it reduces weight without sacrificing strength; (3) by welding, and (4) by turnbuckles or other mechanical arrangement. The cost of welding and mechanical connection is usually considered prohibitive.

In order to resist the diagonal tensile stresses induced in a beam by the action of the shearing force, stirrups are frequently introduced extending between the tension and compression members. They may be considered as the web members of a truss system, the triangulation of which will vary as they are placed vertically or diagonally.

The shape and position of these stirrups constitute the chief claims of several "systems of reinforcement" which have already made names for themselves in concrete buildings on land. The most important of these "systems" which have been used in the construction of concrete ships are as follow:—

Edmond Coignet's system (shown in *Figs.* 48 *and* 49). *A* indicates the principal bars subject to tension, *B* secondary bars working in compression, *C* stirrups to resist shear, *D* principal bars in slab, and *E* secondary bars in slab. The principle of the beam is the introduction into the compressed portion of the concrete of the secondary bars over which the stirrups or shear members are hooked. The stirrups on shear members, which connect together the concrete working in compression and the bars working in tension, increase the resistance to shearing and also the compressive resistance of the concrete. Where the stirrups pass round the bars, they are fastened by means of annealed wire so as not to be disturbed when the concrete is applied. The skeleton reinforcement is prepared in advance, and stacked till ready for use. As the spacing of the stirrups is proportional to the shearing stresses, they are closer together near the supports where the maximum shearing stresses occur. Much importance is attached to the fact that both stirrups and the main bars are of round section, so that the line of contact between them is a mere line.

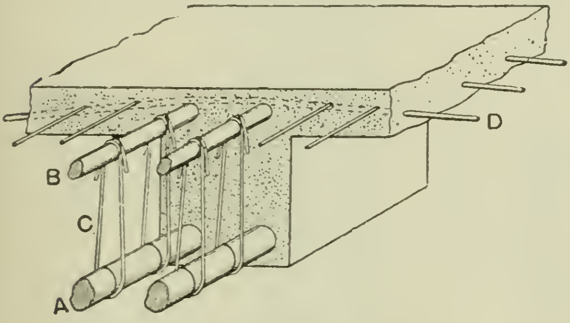


Fig. 48. Coignet Beam and Slab.

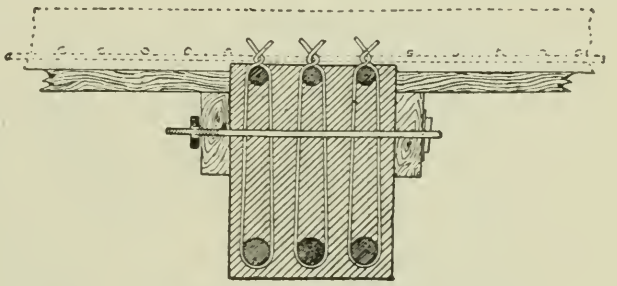
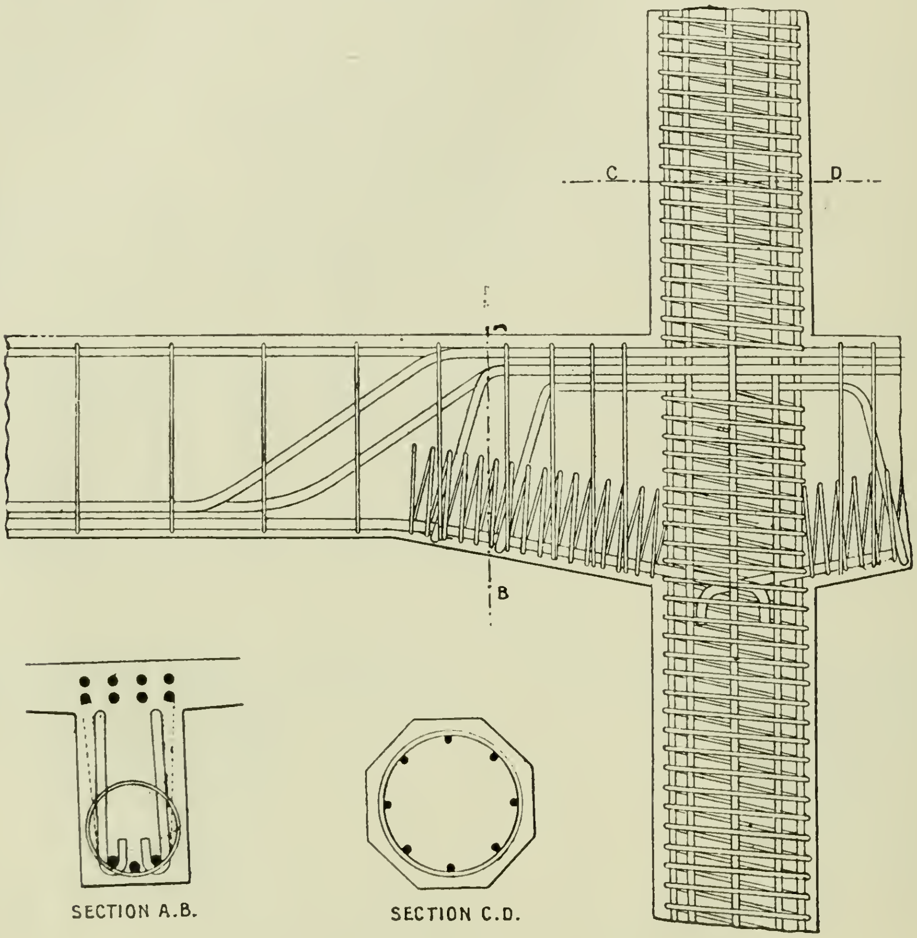


Fig. 49. Coignet Beam Reinforcement supporting Floor Slab Centering.

In some later types of Coignet beam the lower bars shown in the previous figure are replaced by a group of bars of smaller diameter, their ends being bent upwards at an angle of 45° and hooked over the top bar. The sectional area of the reinforcement is greatest in the middle portion of the beam, where the bending moments are higher, and the bars are spaced closer together near the support as in the previous example. The bars are bound together with annealed wire as before. The bars do not lie in contact one with another, there being a space of at least ¼ in. between them into which the concrete flows.

The *Considère system* (*Fig.* 50) is based on the theory that the greatest strength is obtained by longitudinal bars surrounded by spiral reinforcement, the distance between the coils being sufficiently small to resist the lateral or radial expansion of the concrete. Where a compression member is required, a spiral coil of round steel is inserted near the top surface. Occasionally beams are additionally reinforced against shear stresses by means of thin steel rods which are lapped round the tension and compression bars. In addition to the above, Considère sometimes inserts an extra reinforcement (a spiral coil of round steel laid nearly horizontal) in that part of the concrete which is in compression near the supports of a continuous beam. The slab reinforcements between the beams consist of round bars bent up over the supports at each end, there being, in addition, round bars which cross the other reinforcements at right angles.



SECTION A.B.

SECTION C.D.

Fig 50. Showing Considère System of Reinforcement.

In *F. Hennebique's system* (*Figs.* 51 *to* 56 inclusive) thin bars or rods and stirrups are placed in those parts of the structure where a stress diagram indicates they are required, the stirrups taking the shear and the bars the horizontal and diagonal tensions. In a beam for the tension just stated the stirrups are usually placed uniformly except at the ends, where they are placed closer together as the shear stress is greater. When thus placed, they cross numerous lines of maximum stress and are therefore very efficient, whilst their shape prevents them from interfering with the tamping or ramming of the concrete when the latter is being "placed." The stirrups also form an effective web connection between the tension and compression portions of the beam. They are bent in such a manner as to grip the bars too tightly for the stirrups to be displaced, the flattened and opened ends securing additional anchorage. In beams that are continuous over intermittent supports, the ends of the bent-up bars are carried horizontally across the supports and terminate near the points of contraflexure (see *Fig.* 53). The inclined bars in each span, and the horizontal ends of other inclined bars projecting from the adjoining spans, then resist the tensile stress occurring in the upper part of continuous beams between the supports and the points of contraflexure.

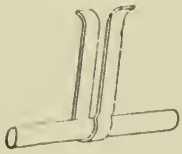


Fig. 51. Hennebique Stirrup Rod Tension Bar.

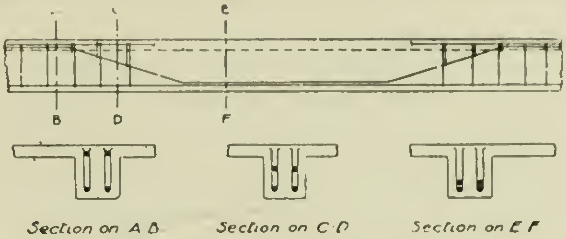


Fig. 52. Simple Hennebique Beam.

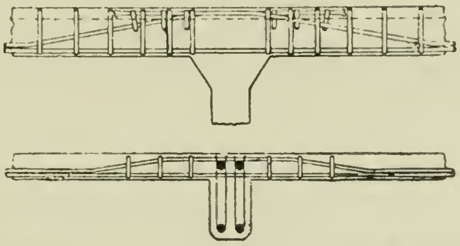
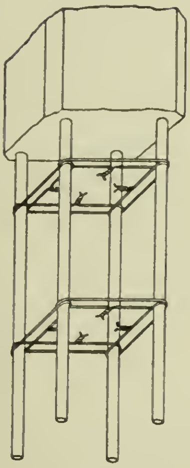


Fig. 53. Hennebique Beams. Continuous over Intermittent Supports



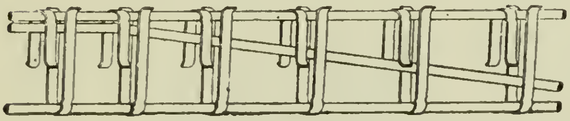


Fig. 54. Beam Reinforcement with Compression Bar and Double Stirrups.

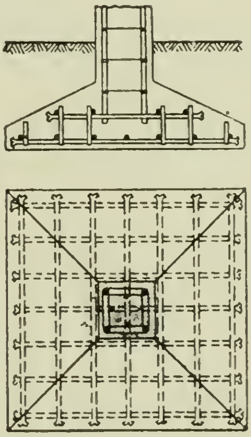


Fig. 55. Hennebique Column.

Fig. 56. Base of Hennebique Column.

It is sometimes advantageous to employ compression bars near the upper surface as shown in *Fig.* 54, which type of beam has advantages when a very heavy load has to be carried by a beam of comparatively small dimensions. The double stirrups will be noticed.

Where unusually heavy loads have to be carried by beams whose dimensions must be kept within comparatively small limits in order to comply with structural or architectural requirements, and in some structures where the spans of continuous beams are liable to variable and unequal loadings, it is desirable to use compressional reinforcement. In the Hennebique system the beams are provided with stirrups for withstanding tension on diagonal planes, and in addition with a series of inverted stirrups passing over the upper bars and anchored in the lower part of the beam. Both the compression and tension bars are carried across the supports or through columns, and so perfect connection is provided between adjoining spans.

The complete arrangement shows that the system of main bars and double stirrups ensures ample resistance to horizontal tension and compression, and to tension and compression in diagonal directions, while at the same time it constitutes, after incorporation in the surrounding concrete, a truss of great rigidity and extraordinary capacity for withstanding deflection.

A typical Hennebique column is shown in *Fig.* 55, the vertical reinforcement consisting of plain round bars, and the auxiliary reinforcement being formed of links of $\frac{3}{16}$ in. steel wire applied in sets of four, one link passing round the two verticals on one side. The links brace the longitudinal bars and support the concrete laterally. This method was introduced many years ago, and has given satisfaction in thousands of cases.

Fig. 56 shows a column base, the horizontal steel reinforcement distributing the force transmitted by the vertical bars. The lower portion of the concrete is reinforced by a double system of bars laid at right angles with one another so as to provide for the tensile stresses caused by the bending moment developed by the central load and the vertical reaction of the bottom of the vessel or of the water beneath. Resistance to compression is provided entirely by the upper portion of the concrete, and diagonal tension is taken by the vertical stirrups applied as in beams. A column base of this description virtually represents cantilever construction.

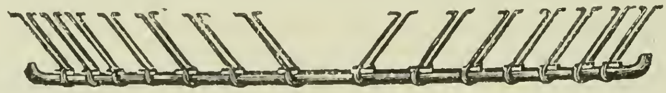


Fig. 57. "Keedon" Beam Reinforcement.

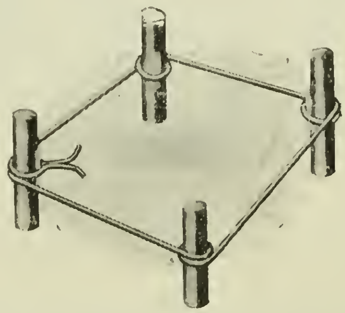


Fig. 58. "Keedon" Column Reinforcement.

In the *Keedon system* (*Figs.* 57 *and* 58) the stirrups are twisted around the bars and are wedged securely in position.

In the *Kahn system*, the stirrups are replaced by strips or webs, which are made by cutting and bending upwards a portion of the bar (*Fig.* 59). At the centre of the bar, where the horizontal tension is greatest, the web is left intact on the bar, and there serves as an additional reinforcement. The stirrups are part of the original metal of the bars, being merely sheared and bent, whereas in the original Kahn bar holes were punched in it and the shear members fastened in these holes. The Kahn trussed bar, it will be understood, is sent to the site complete, ready to be incorporated in the concrete as a single unit. In the construction of concrete ships, the objection to this arrangement is its lack of flexibility in design ; in the Hennebique and Keedon systems, the stirrups can more readily be placed where required. A further practical disadvantage of bars with web members attached at the sides is the excessive width of the bars in proportion to their tensile resistance. In consequence, bars of this type cannot be used with economy in beams having to carry loads, as the width of the beams must be very great to enable the requisite number of bars to be applied, the excessive width naturally representing waste of material and labour. Moreover, the width of the bars is apt to constitute an obstacle to the flow of the concrete, making it difficult, if not impossible, to fill every part of the moulds, and to obviate the presence of voids between and under the reinforcement. The use of a very fluid concrete only introduces more serious difficulties, as it fills the moulds with concrete of irregular composition, because the aggregate and heavier particles of sand must necessarily settle to the bottom.

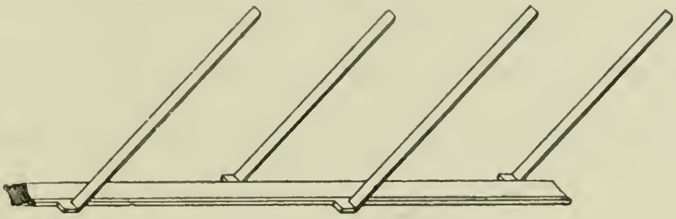


Fig. 59. View of Kahn Bar.

The most rational method in the design of reinforcement, whether in beams, columns, piles, or other structural details, is to employ forms of steel which permit the engineer to vary the spacing of the main and auxiliary bars at pleasure, and to determine by calculation the number and sectional area of the stirrups as demanded by the intensity and distribution of the stresses in every part of the construction.

Expanded metal consists of rolled steel of various thicknesses, cut and expanded by machinery into meshes of various shapes, the material being obtainable in a number of different strengths or weights. There are thirty varieties of this material, the variations being in the size of mesh, thickness of strands, the weight per yd. super, etc. The rib mesh is made in five varieties ; however, for concrete work the diamond mesh material is chiefly used.

What is known as the expanded steel bar is a bar from which a series of meshes has been expanded. It is claimed that each bar is a complete unit, comprising tension and shear reinforcements, and as its members are rigidly connected they cannot get out of place during the concreting. When expanded metal is used in connection with these bars, the ends of the sheets may be wired to or bent over and lapped on to the web of the bars, thus securing continuity of reinforcement.

In concrete vessels, the netting or mesh work of expanded metal is made to conform to the shape of the hull, and is then covered on both sides with concrete. Additional reinforcing bars or rods may be used as required.

Richard Johnson, Clapham & Morris, Ltd., use a form of *wire netting* (*Fig.* 60) which may be suitable as a reinforcement for small boats and for parts of larger vessels.

Instead of plain steel rods or bars, those of special shapes are extensively used. Thus *indented bars* (*Figs.* 61, 62) are of square or round section, have projections or indents on each side, these indents being sufficiently deep to prevent the concrete slipping along the bar. These bars are made of steel with a somewhat higher proportion of carbon than is usual in reinforcement, as such steel can be stressed more severely The ends of the bars are bent where required to take additional shear stresses.

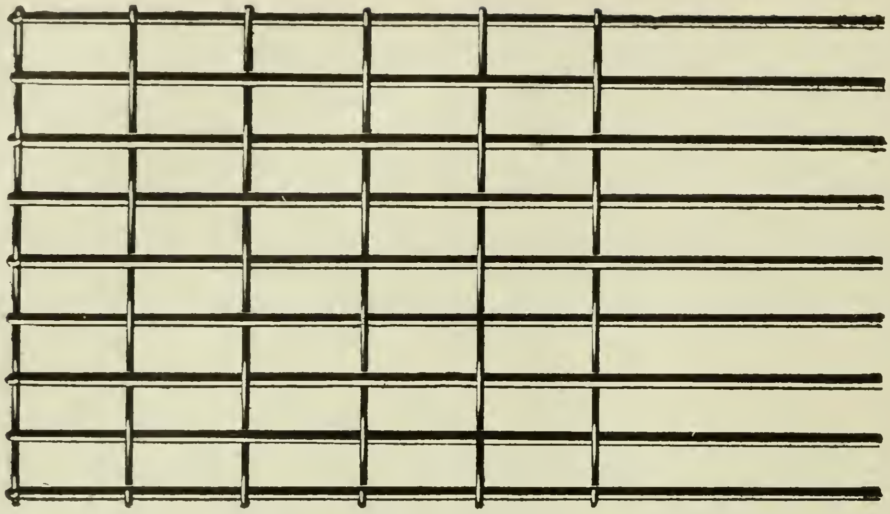


Fig. 60. Johnson's Steel Wire Lattice.

The makers of the indented bars claim that with their bars "there is so close a bond between the concrete and the steel that it prevents undue extension of the concrete towards the beam ends, and the concrete is thus bound together where it is exposed to the greatest shearing stress and diagonal tension, so that it is able to resist shear of itself to a far greater extent than is the case when diagonal tension cracks can take place in the concrete, and thus reduce its resistance. There is no doubt that the concrete itself plays a very important part in resisting shear when it is absolutely prevented from cracking by the use of a mechanical bond bar."

A further advantage claimed in favour of the use of indented bars is that, with them, "Tests and actual practice conclusively prove that no cracks of sufficient size to admit moisture to the steel can occur in the concrete until the yield point of the steel has been reached. At this point, however, the whole member will be practically disintegrated, owing to the complete inability of the concrete to stretch to the same extent as the steel. In other words, the yield point of steel reinforcement is the critical point at which the structure will fail, and it is utterly fallacious to consider the ultimate or breaking strength of the steel as the critical point."

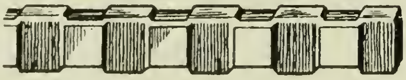


Fig. 61. Square Section Indented Bar.

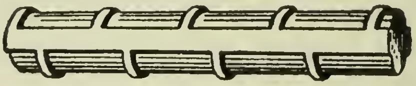


Fig. 62. Rod Section Indented Bar.

The objection is sometimes raised that the ridges and sharp angles of indented bars injure the concrete when the structural members are in a state of strain. The effect is, however, too small to be appreciated in practical construction, and no failures have yet occurred through it.

Spiral bars have spiral grooves running along their outer surface, and have the advantage over smooth round bars of rendering crooking or fishtailing the end of tension bars unnecessary. The spiral grooves secure a strong mechanical bond, and enable the bars to be used for working stresses up to 30,000 lb. per sq. in., or 50 per cent. more than is the case with smooth bars; consequently, a large reduction may be made in the quantity of metal used. The lateral bending resistance is also much greater than that of smooth bars.

A large number of other shapes of reinforcing bars and meshes have been devised, but the foregoing are sufficient for the reader to gain some idea of the arrangements most commonly used.

Owing to the manner in which the steel is distributed in a concrete vessel, it is used far more economically than in a steel one, and thus effects a considerable saving. In a general way there is assumed to be no loss of strength at the clamps in the steel reinforcing bars, and this gives the concrete ship an advantage over the steel one. In the latter there is always a loss of strength brought about by the plates and bars being punctured for rivet holes. The loss on this account will vary from 10 to 15 per cent., and in practice means that this extra amount of steel must be put in a steel ship over and above the amount that would be required if there was no such loss of strength.

There is also a further advantage in that there is practically no waste of steel in the concrete ship, since all the bars are ordered practically to the exact lengths. In a steel one, a margin must always be allowed on the plates and bars for working them into the ship, and the scrap on this account will generally be about 10 per cent. There is also no loss of strength where longitudinal and transverse bars cross one another, since the bars can be carried continuously right through. In a steel vessel, one or the other must be cut and riveted, bringing about a considerable reduction in the strength. In consequence, therefore, less steel is required in the reinforcement of a concrete vessel than in one built entirely of steel.

In designing concrete vessels it is usual to allow a stress of 8 tons per sq. in. on the steel.

CONCRETE.

The concrete used in shipbuilding must be of first-class quality and possess the following properties :—

(*a*) It must be sufficiently strong to resist any crushing stresses which may act upon it.

(*b*) It must be sufficiently tough to resist accidental impacts, knocks, and blows.

(*c*) It must not be brittle.

(*d*) It must be impervious to water.

(*e*) It must not expand or contract unduly.

(*f*) It must not be seriously affected by the impurities in the water with which it comes into contact. This is specially important in (i) canals in certain industrial centres in which the water is contaminated with "chemicals," and in (ii) sea water.

(*g*) It must be uniform in composition ; some concrete is too irregular.

The *value* of the concrete depends upon the nature and size of the particles of sand, gravel, or other aggregate used, and upon the proportions of these and of the Portland cement employed to bind them together.

The *sand* should be clean and sharp, with hard, clean grains all of which pass through a 15 by 15 sieve ; the grains should vary regularly between coarse and fine, without a large proportion of either extreme. Sand flour or dust should be removed, if necessary, by washing the sand previous to use. A useful specification by G. T. Owens Thurston requires a sand which remains wholly on a 100 by 100 sieve, leaves a residue of 61 per cent. on a 50 by 50 sieve, and of 14 per cent. on a 20 by 20 sieve. This contains a notable proportion of finer sand than is generally regarded as suitable for reinforced concrete ; most of the leading concrete specialists regard all particles passing through a 50 by 50 mesh as harmful. The standard Leighton Buzzard sand used for testing cements passes completely through a 20 by 20 sieve and is retained on a 30 by 30 sieve ; this is coarser and more uniform than requisite for use on a large scale. Crushed stone is usually more suitable than natural sand as the grains are more angular and interlock better with each other.

The *aggregate* is preferably composed of crushed granite chippings which have been screened so as to remove all those which are more than $\frac{1}{4}$ in. in diameter, and then washed to remove all dust. If gravel, flinty shingle, or crushed stone is used, the particles should all be small enough to pass through a sieve of $\frac{5}{8}$-in. mesh and be retained on one of $\frac{1}{8}$-in. mesh.

Limestone is seldom suitable, and crushed bricks should be avoided, though brick dust may be used to replace part of the finer sand. In 1887 D. Wilson patented the use of burned clay (such as brickbats) as an aggregate for cement vessels.

The pieces of aggregate should be sharp and angular, but not flaky, and of a hard and dense material with a high resistance to crushing and tensile stresses. Materials such as pumice stone, ashes, and coke breeze, which are used in land work for making light concrete, are too porous, absorb a large weight of water, and give too weak a concrete ; they cannot be utilised for ships. Sandstone gravel must be subjected to a particularly careful scrutiny before being allowed for ship construction, as when porous and friable it is a source of weakness, being deficient in density and crushing strength. In fact, sandstone is so variable in its physical properties that it is seldom desirable to use it as an aggregate for reinforced concrete in ships.

Small-sized particles of aggregate are essential, as the thickness of the concrete must be kept at a minimum, and when allowance is made for the reinforcement there is no space for large pieces of stone or gravel. In many cases it is preferable to purchase the aggregate in pieces of moderate size, and to crush and wash them immediately before use. The machine used for this purpose should be of the jaw-breaker or hammer type, as edge-runners and cylinder-mills produce too much dust.

Some engineers have suggested the total abandonment of aggregate and the substitution of sand, but this has been proved to be so unsatisfactory in ordinary reinforced concrete work that it cannot be recommended for ship construction.

Care must be taken that the material is as uniform as possible, and when charging the mixing machine the aggregate should be taken from various places so as to secure the requisite uniformity.

Several other aggregates have been suggested with a view to producing a lighter or denser concrete, but without much success. One of the most recently patented is dried and pulverised moss mixed with four times its weight of iron ore. The value of this material has yet to be proved. There is scope for inventors to produce an impervious aggregate of a less weight than, say, 100 lb. per cu. ft., which is not affected by prolonged exposure to water and to heat, and is sufficiently homogeneous in structure.

The use of filling materials of very low density has attracted several inventors. Cork, moss, and various fibrous substances have been employed, some of them forming part of the aggregate and being mixed with it, whilst others form a distinct part of the hull. A typical example of the latter is that patented by Paul Pons (French Pat. 450,834), in which the slabs of compressed cork or other material, *j* (*Fig.* 63), are held in place by wooden strips, *p*, *g*, placed at their ends. Distance pieces, *t*, keep the reinforcing bars, *r*, *s*, about $\frac{1}{2}$ in. away from the cork slabs, and supplementary bars, *i*, *m*, with hooked or bent bars, *o*, add to the strength of the structure, and the concrete *h* fills the intervening spaces and forms the surfaces of the hull.

The *cement* should be Portland cement, corresponding to the British Standard Specification. If desired, a rather more finely ground cement—leaving a residue of only 5 per cent. on a 180 by 180 sieve—may be used, but care should be taken that it does not set too rapidly. In all thin concrete, it is preferable to use a cement which sets moderately slowly. This is specially the case in building concrete ships.

It may be assumed to weigh 84 lb. per cu. ft.

WATER.

The *water* used in mixing the concrete should be fresh, clean, and soft. Sea water is *very* objectionable, and so is spring water highly charged with mineral or organic matter, as they both produce porous masses which are liable to disintegrate rapidly.

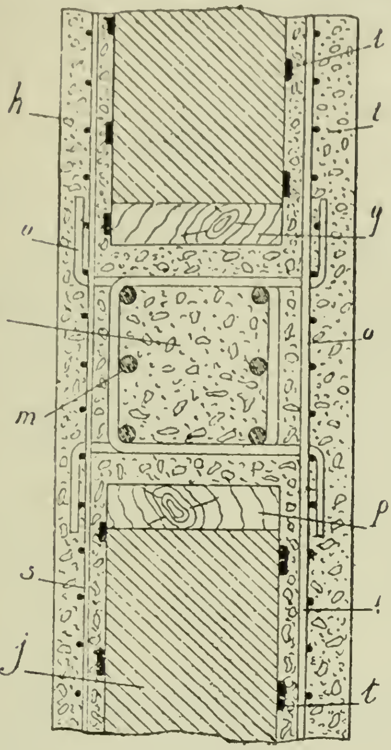


Fig. 63. Paul Pons' Patent,

The *proportions* of cement, sand, and coarser aggregate should be regulated by the volume of voids or interstices between the particles. These will vary with the source of the material and the sizes of the particles, and should be found by trial. An ideal mixture is one in which all the interstices between the particles of coarse aggregate are filled, as far as possible, with the sand, and the interstices between the sand grains are then filled with cement. An additional quantity of cement will also be required to coat all the particles of sand and aggregate, and to bind them strongly together. To attain this object, it is necessary to determine the proportion of voids (*a*) in the aggregate, and (*b*) in mixtures of aggregate and sand in various proportions. This is easily done by placing 1 cu. ft. of the wetted and drained material * in a suitable vessel and pouring in water from a measure until all the interstices are filled. The mixture of aggregate and sand which requires the least quantity of water to fill the voids will be the most suitable for the purpose.

The amount of cement required is that corresponding to the volume of water required to fill the voids plus an allowance for coating the particles; for the latter 10 per cent. is customary, though based on a flimsy foundation.

It is unwise and even dangerous to use fixed proportions of the various materials without making any preliminary determination of the voids, and the absence of such a test is a frequent cause of porous and weak concrete.

As illustrating the proportions commonly employed by shipbuilders, the Table I. is interesting; all the quantities are by *measure*.

The mixtures in Table I. contain twice as much cement as is customary in reinforced concrete for land structures, the additional richness being considered to be desirable on account of the thinness of the concrete. It is a mistake to suppose that a large proportion of cement is always an advantage; on the contrary, an excess of it leads to undue shrinkage and cracking of the concrete. There appears to be a definite percentage of cement above which it is useless to go, as the concrete is not improved. This maximum point is about 30 per cent. of the finished concrete, but varies with different aggregates.

As previously suggested, in work of the importance of concrete shipbuilding the contractor will be well advised to mix up cubes in which the ratio of fine to coarse material is varied slightly. When these are set and dried out, he can weigh them and soak in water, weighing the wet briquettes at intervals after wiping them, to see which is absorbing the least amount of water. For all ordinary purposes, he can take it that the one which absorbs least water will be best for his purpose all round, both in strength and permeability.

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* The determination of the percentage of voids in a dry-rammed aggregate without any cement is of no value.

TABLE I.

Vessel.	Builder, etc.	Cement.	Fine Aggregate (Sand).	Coarse Aggregate (Gravel, etc.)	Mixed Aggregate.	Remarks
Motor boat ...	Porsgrund Works, Norway	1	—	—	2	No stones
Motor boat ...	W. Dowsey, U.S.A.	1	1½	—	—	—
Barge	Weller ...	1	—	—	4	Small gravel
Barge	A. A. Boon, Holland	1	1½	1½	—	Sand and gravel
Barge	Gabellini, Italy ...	1	1½	3	—	Sand and ¾-in. aggregate
Barge	Hennebique ...	1	1¼	2½	—	Sand and shingle
Barge	N. Fougner, Norway	1	1½	3	—	Gravel or stone under ½-in. diameter
Motor cargo boat ...	W. Pollock ...	1	—	—	3	Sand and gravel
Cargo boat	W. G. O. Thurston, Barrow	1	1¼	2½	—	Waterproofing agent added
Cargo boat ...	M. Denny... ...	1	1⅛	2¼	—	Sand and granite
Pontoon	Porsgrund Works, Norway	1	—	—	3	Plenty of small stones
Caisson	Porsgrund Works, Norway	1	1¾	3½	—	Sand and gravel
Average (excluding small boats)	—	1	1.4	2.8	—	—
Average for land structures	—	1	2	4	—	—

It has been suggested by various engineers that a much poorer concrete might be used with safety, say a 1 : 2 : 4 or 1.2 : 2 : 4 concrete if a good rich rendering were applied later to the external surface of the sides and bottom, but such a rendering would be extremely difficult to make properly, especially when nearing the bow and stern, and with the hard wear and tear to which ships are submitted it would soon come away in patches. This objection might be overcome by placing the richer concrete in the mould at the same time as the poorer one, but the juxtaposition of two such different concretes is seldom, if ever, satisfactory. It is in every way better to use a uniformly rich mixture which will give a very good face to the concrete when the moulds are struck off, prove quite impervious, afford a high crushing strength, and can be easily worked into the moulds.

For grouting purposes and for fitting various iron parts in position after the concrete structure has been cast, it is better to use an equal mixture of cement and sand rather than pure cement, as the latter is more liable to contract and come away from the ironwork.

Concrete which is too weak has probably been made of badly graded materials or mixed with too much water. Porous concrete may be produced in the same manner, or by the use of too porous an aggregate, such as coke breeze, or a porous sandstone.

There are two kinds of cracks that appear in concrete—hair or surface cracks, and setting or hardening cracks. The former are caused by a film of richer concrete getting to the surface, or through the concrete being faced with neat cement, and thus constituting a different mixture from the bulk of the concrete with a different coefficient of expansion and contraction. The latter cracks are caused by the difference in contraction of the concrete in air, as compared with the contraction when in water.

Surface cracking may be avoided by keeping the aggregate in the concrete well to the surface, and contraction cracks by keeping the concrete well wetted during its process of setting.

The volume of water should not exceed the volume of cement, and if the mixture can be worked satisfactorily the best results will be obtained when the volume of water used is only half that of the cement. In many instances where the concrete has proved defective, this has been due to the use of too much water.

When properly made and hardened the concrete may be assumed to have the following working limits for safe stresses.

Item.	Working Stress, lb. per sq. in.	Ultimate Stress, lb. per sq. in.
Compression in beams	750	4,000
Compression direct	700	4,000
Shear	70	280
Adhesion	60	240
	100	500

Although it is customary to consider the resistance to crushing as the most valuable factor in judging the quality of a concrete, it is by no means certain that this is the case. Dr. Emperger, for instance, has long maintained that a better criterion is the load required to fracture a miniature beam standing on supports placed at a pre-arranged distance apart. The advantages of this test have long been recognised, and its indications are specially applicable to concrete vessels.

Permeability.—If properly prepared, fresh concrete is very slightly pervious to water, but its porosity rapidly diminishes, and it should become quite impervious after having been immersed in water for a few weeks. Much of the porous concrete observed in land structures owes its permeability to the fact that it has not been supplied with sufficient water during the hardening or maturing period. This defect is readily overcome in concrete vessels which may be launched soon after their construction.

Concrete which remains permanently porous has usually been improperly graded, has been mixed with too much water (17 per cent. by weight is usually ample), or it contains an unsuitable (porous) aggregate. It may be rendered impervious by coatings of water-glass, aluminium fluoride, tar, or bitumen, but these are not satisfactory when applied to concrete vessels, as they soon wear away and require frequent renewal.* Moreover, their action is somewhat uncertain, and as the use of a porous concrete in ships involves a serious reduction in their durability, it is necessary that sufficient care should be taken to use concrete which has been properly made from suitable materials.

Of the various methods available for rendering concrete impervious to water, the only one which can be regarded as satisfactory for seafaring vessels is to add about 5 per cent. of a suitable water-repellent to the dry concrete. These waterproofing agents are sold under various trade names. Of these, the vegetable and animal oils and emulsions are not satisfactory for ships, and mineral oils are but little better. Soaps are better waterproofing agents than oils, because they may be distributed more uniformly throughout the mass; a specially prepared material of this class—Pudlo—has proved particularly satisfactory.

The use of a solution of silicate of soda instead of plain water in order to produce an impervious concrete has been patented by D. Wilson (16,530—1887).

It must be observed, however, that all waterproofing agents are merely palliatives, the chief purpose of which is to reduce damage done by carelessness or lack of skill in the production of the concrete. All such agents necessarily effect a reduction in the strength of the concrete—a serious matter in seafaring vessels. As already explained, if the concrete is made of suitable materials, carefully graded and proportioned and properly mixed, it will be sufficiently impervious for all practical purposes, and will be far more satisfactory than a less skilfully prepared concrete to which a waterproofing agent has been added. The fact that most of the concrete vessels now in use are quite watertight without any waterproofing agent having been applied to them is conclusive evidence that such agents are not essential.

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* The hull of a 1,000-ton motor-boat built by the Association Commerciale de Constructions Maritimes was given two coats of hot coal tar, and the deck was faced with cork powder mixed with a magnesium oxychloride cement.

If it is feared that the absence of a waterproofing agent involves too great a risk, it is desirable to replace a portion of the sand by finely ground trass or an artificially prepared equivalent material which will fill up the voids in the concrete, and will at the same time enter into combination with the lime set free by the action of water on the cement. Such a material is quite different from the ordinary waterproofing agents, and is in no sense a water-repellent, but if properly used it is extremely effective in rendering concrete impervious to water. Incidentally, it adds slightly to the strength of the concrete.

Effect of Sea and other Water on Reinforced Concrete.—The action of sea water is partly physical, and the impact force of the waves and the grinding action of sand, shingle, and pebbles are not infrequently of greater importance than the purely chemical corrosion. Against much of this purely physical action man is powerless ; he can only reduce it by the use of hard aggregates and of dense, well compacted concrete sufficiently rich in cement to resist for a reasonable number of years. That such remarkable resistance can be obtained as in some marine works which have been constructed is, in fact, one of the wonders of modern engineering. Strength and density are the two chief properties on which modern engineers rely in constructing concrete which will withstand the physical action of the waves.

Experiments on a large scale in Germany and Copenhagen have shown that the succession of saturation, drying, freezing, etc., to which marine work is subjected by the changes in the water level due to the tides, also has a most important effect in causing the destruction of the concrete. The action of frost is particularly powerful, and the utter impossibility of protecting embankments and other marine works from its action makes this all the more serious in considering the durability of concrete ships.

A further factor which has not received the attention it deserves is the percolation of salt water into the interior of the concrete, and the crystallisation of the salt as the water evaporates. The effect of this crystallising in cement blocks which are only immersed at long intervals has been found to be similar to that of frost.

The chemical action of sea water is due to that of a variety of substances, of which carbon, sulphur, and magnesia compounds are usually considered to be the most important so far as the concrete is concerned ; the salt acts chiefly on the reinforcement. Very little is known of the details.

MEMORANDUM.

The Concrete Ship "Faith."—On November 21st the reinforced-concrete ship *Faith* which was launched in San Francisco last March, reached New York after a voyage in which stops were made at Vancouver, Lima, New Orleans and Havana, and totaled about 12,000 miles. On November 25th she was put in dry dock at the Erie Basin in Brooklyn. So far as could be seen in an examination of the outside of the shell and bottom by a member of the staff of *Engineering News-Record* immediately after the docking, there are no cracks in the hull, nor is there any sign of rusting from lightly embedded steel. There was some slight marine growth, but in general the hull was remarkably clean. Examination of the inside of the shell is not readily made, because the wooden sheathing is fastened to the frames, but the holds were quite dry, and the shell, where it could be observed, showed no cracking. The ship encountered very heavy weather throughout the voyage, but handled well.

E8134.—W.H.S. & S.

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REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER III (*concluded*).

THE MATERIALS USED IN CONCRETE VESSELS

SEA water in the neighbourhood of land usually contains a notable amount of carbon dioxide, and this dissolves out a portion of the lime in the concrete, leaving the mass more open and accessible. Generally speaking, however, the corrosive action of sea water is confined to the material quite close to the surface of the concrete, as a redeposition of some of the dissolved matter not infrequently occurs in the pores of the concrete. Excessive action in a compact concrete is also prevented by the slowness with which the water can enter the material.

The constituent of sea water which is generally regarded as being the most detrimental to concrete is magnesia in the form of magnesium sulphate, or chloride, as these salts decompose cement, forming calcium sulphate and chloride. The calcium sulphate may then form crystalline calcium aluminium sulphate with considerable increase in volume, and thereby tend to destroy the concrete. Hence, the effect of sea water is greatest where the concrete is porous, and is at a minimum when the concrete is almost impervious.

C. von Blaese has found that half the lime in a cement is removed as calcium chloride when the cement is treated with an excess of a 6 per cent. solution of magnesium chloride. So intense a reaction is disputed by Kallauner, though the latter agrees that all magnesium salts decompose cement, the chief reaction occurring between them and the calcium hydrate formed during the setting, colloidal magnesium hydroxide and a calcium salt being produced. In contradiction to von Blaese, Kallauner also observed that where the calcium salt is almost insoluble in water the volume of the concrete was altered and cracks formed ; when soluble calcium salts are produced the volume of the cement is not affected, but its strength is greatly reduced.

In other words, it is not the small proportion of sulphate in the original cement which is important in submarine work, but the permeability of the concrete which permits the magnesium sulphate in the sea water to react with the cement. If this is the true explanation of the destructive action of sea water, the latter may be overcome by the use of an impervious concrete, prepared from a more finely ground cement and a more carefully graded and proportioned aggregate.

The precise reactions produced by magnesia compounds have not, however, been studied with great accuracy, and there is ample room for a further investigation of the subject. Moreover, the calcium sulphate in sea water appears to have a direct chemical action on cement, according to E. Candlot a calcium sulpho-aluminate being formed.

Water containing salts and acids in solution has a very serious effect upon badly made and porous reinforced concrete. Its effect has been clearly demonstrated by many experiments—chiefly made in the United States—and is found to be largely due to the action of the metal in the reinforcement on the salts in the water. In the simplest case (examined by Prof. H. J. M. Creighton), where a piece of bright steel was covered with porous concrete and placed in a solution of common salt, the iron was rapidly converted into a hydrated oxide, and this exerts a pressure which is sufficient to crack the concrete and cause its rapid disintegration. The action cannot be prevented so long as the metal is allowed to come in contact with the salt solution, but if they are kept separate by means of an impervious covering, no disintegration will occur.

Sea water has little or no action on the concrete itself (*i.e.*, apart from the reinforcement) if the concrete is properly made and is reasonably impervious. If, as should be the case, the surface of the concrete is an impervious skin of very fine texture, the concrete will not be affected so long as this skin remains unimpaired.

Most of the investigations of concrete which has been disintegrated by sea water have dealt with masses which have not been prepared with the same skill as may be expected in the construction of concrete vessels, and the most serious disintegration has been found to occur at the junctions between new and older concrete, and in portions which show evidence of carelessness and defective grading, combined in some instances with the use of entirely unsuitable materials.

The following carefully prepared summary indicates the consensus of opinion of leading authorities on this subject :—

(*a*) Little, if any, damage is done to even the poorest concrete structure below water.

(*b*) The principal destructive actions occur between tides, generally at the mean-tide line.

(*c*) Where the concrete has disintegrated in sea water, this is undoubtedly caused by freezing, for the reason that in tropical waters, where there is no freezing, the structures do not show this deterioration, excepting in cases where sea water has been used in the mixing and the concrete has been placed through sea water, thereby producing an inferior structure unsuited to resist sea-water action.

(*d*) While there may be some chemical action after the concrete is weakened through freezing, it is a fact that there is little or no chemical action on a properly proportioned, mixed, and placed concrete.

(*e*) It seems to be in every respect desirable that the cement used in making concrete to be exposed to sea water shall contain sufficient hydraulic material as will satisfy whatever excess lime there may be in the hardened cement. This is accomplished in many parts of Europe through the addition of trass or pozzolana to hydraulic cement. The trass combines with the lime set free from the cement, and so increases its strength and renders it stable in sea water.

(*f*) It should be understood that the concrete must be rich in *slow-setting* cement.

(*g*) It is quite apparent that one of the prime essentials for a concrete structure that will be immune against sea-water action is that the surface shall be dense and impervious. An attempt has been made to secure this condition by applying mortar under an air pressure of upwards of 30 lb., and while this undoubtedly increases the density as compared to hand methods, nevertheless it remains to be seen whether it achieves the object desired.

(*h*) Good practice demands that the concrete shall be mixed a sufficient length of time, without too much water, so that the resultant mass has a viscous consistency and will flow readily without the ingredients separating. If such a concrete is deposited under conditions which will prevent the sea water permeating it before it has set, the product will afford excellent resistance to sea water. Another method proposed has been to deposit the concrete in tremie, as with this form of construction only the upper surface comes in contact with the water, and there results a concrete which is not affected by sea-water action.

When reinforced concrete is used in sea water, it is essential that the aggregate shall be a hard, dense material of low absorption, and that the reinforcement be protected by a coating of at least 1 in. of trass-like mortar.

A still more recent statement is that of R. J. Wig (Bureau of Standards, U.S.A.) and L. R. Ferguson (American Portland Cement Association), who have examined all the concrete structures exposed to sea water in the United States, besides many in Canada, Cuba, and Panama, and have reported that :—

" The conditions which concrete structures in sea water are called upon to resist are most severe, and only concrete of the best quality placed with the utmost care should be used. If this is done and the concrete is properly protected by adequate fender systems, a permanent structure can be secured. A well made concrete properly placed, if not subjected to mechanical abrasion or erosion, is permanent in sea water. If the structure is so located that the concrete would under natural conditions be exposed to mechanical abrasion, chemical disintegration can be prevented only by the provision of a fender system of other protecting medium. Disintegration by chemical action will be very slow, unless there is frost action or appreciable mechanical abrasion continually to remove the decomposed cement products as they are formed."

Of the various means for protecting the reinforcement from corrosion, galvanising is the best known, but as the result of special investigations on the subject Gardner has recommended the use of paints the vehicle of which contains boiled or bodied oils or products which dry to a fairly saturated film, oils which dry by semi-polymerisation rather than oxidation, and oils which dry to a flat rather than a highly glossy surface, while the pigment contains a percentage of pigments which are coarse, and which, therefore, tend to form films having a rough surface, pigments which are inert, and which do not act as conductors of electricity, and pigments which are either basic or of the chromate type. The metal should be roughened by sand-blast previous to being painted. H. J. M. Creighton has suggested that the reinforcement should be covered with a film of a different metal applied by the Schoop metal-spraying process.

It has been shown conclusively that properly made reinforced concrete is able to resist the action of sea water for a considerable number of years, and that if reasonable care and skill are exercised there need be no anxiety as to the effect of sea water on concrete vessels.

The impurities in canal and river water are less drastic in their action on concrete; and, though it is undesirable to expose concrete vessels to the action of acids and other water chemicals, they will be found to resist this action better than vessels made of steel. Many of the impurities in canal water automatically restrict their action, inasmuch as they combine with the outermost layer of concrete and form an impervious coating which prevents the occurrence of any further action.

Coating the surface of the vessels with tar or bitumen may also prove an efficient preservative, but the coating is necessarily thin, and must be renewed from time to time, and it is one to which barnacles, etc., adhere tenaciously.

CHAPTER IV

DESIGNING CONCRETE VESSELS.

In designing any vessel, the first consideration must be given to its ability to resist the destructive forces to which it will be subjected when in use. Beauty of form, lightness, speed, carrying capacity, and all other matters are of secondary importance to strength and durability, though they play an important part when comparing vessels of different types.

Reinforced concrete has been proved in innumerable instances to be an exceptionally strong and enduring material when used in relatively large masses for sea-walls, forts, towers, bridges, and other constructional purpose on land, and the mathematical study of concrete beams, floors, walls, pillars, cantilevers, and other architectural details has been carried out with great thoroughness. For such structures, therefore, the strength and durability of reinforced concrete may be accepted as proved.

The mathematical and physical study of shipbuilding when using wood and steel—either alone or in combination—has also reached a high state of efficiency, and there are many able naval architects whose work has been singularly successful. When the supply of materials to which these gentlemen are accustomed was reduced, it became necessary to find a substitute, and the possible advantages of reinforced concrete were soon realised.

The intrinsic properties of wood and steel are so different from those of concrete that a naval architect who has no expérience of the latter might find serious difficulties in working out the design of a concrete vessel without the aid of someone with a special knowledge of the properties of concrete, just as a " concrete specialist " would undoubtedly produce a vessel greatly inferior in many respects to one produced by a naval architect, because the problems of reinforced concrete construction as applied to naval architecture are very different from those when it is applied to land work. For instance, it is desirable to reduce the weight of the hull and consequently of all the scantlings as much as possible consistent with good work, and therefore the amount of concrete which can be used to surround the reinforcement is much less than in concrete used on land. Moreover, land structures are seldom so thin as the shell of a concrete vessel, and this very thinness produces problems with which the engineer whose experience is confined to concrete bridges and buildings is entirely unfamiliar. By combining the services of these two classes of designer, however, it is relatively easy to produce vessels of any desired size, shape, and carrying power using reinforced concrete as the chief constructional material.

It is not proposed to enter fully into the details of the principles underlying the designing of ships, but merely to indicate the general outlines of this subject, especially with reference to the use of reinforced concrete. For this purpose it is convenient to consider in turn the shape, size, and thickness of the hull, the directions in which the greatest stresses are likely to be applied and the best means of resisting them. It is also important that the vessels should be designed so as to conform to principles which experience with existing ships has shown to be of value, and designers and builders will naturally aim to keep the weight of the vessel as low as is compatible with strength and durability, and to use only sufficient steel to take up the calculated tensile stresses.

An important principle of construction in which vessels of concrete differ from those built of steel or wood is the general arrangement of their chief feature. With one exception—the Isherwood system (*Figs.* 65 *and* 66)—the basis of steel and wooden vessels is a series of transverse frames and beams fitted about 2 ft. apart.

A vessel built of *steel* usually comprises a framing consisting of bars (*frames*) (*Fig.* 64) which form the sides of the vessel and are attached firmly to its bottom. The steel plates which form the *shell* of the vessel are riveted on to these bars. The frames are strengthened by longitudinal bars or *stringers* fastened securely to them. The frames are fixed about 2 ft. apart, the distance between them depending on the nature and size of the vessel. The bars which run lengthwise along the bottom of the vessel are known as *keelsons*; they are strongly riveted to the transverse bars. In this way, aided by many supplementary bars, a framing of extraordinary strength is produced. Each deck is supported by steel beams which are attached to the frames by means of *beam-knees*. These beams also increase the resistance of the framing to external pressure. Pillars are used to supplement the beams in large vessels.

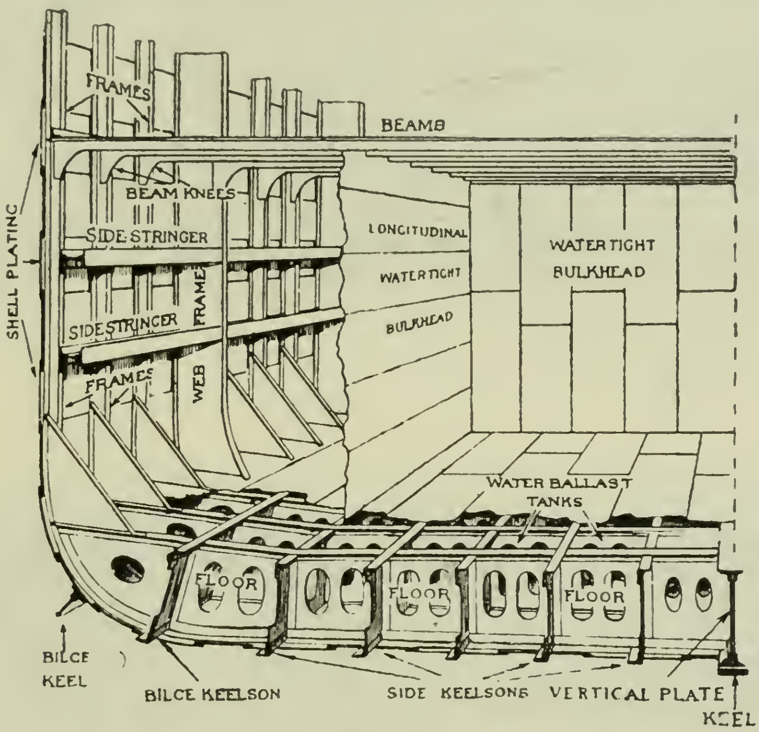


Fig. 64. Cross Section of Steel Ship showing construction.

Vessels built on the ordinary transverse system of construction are lacking in direct longitudinal stiffening to prevent the plating from bending between the transverse supports. When exceptional conditions are met with, either in the case of severe weather or bad loading, or a combination of both, structural damage occurs with more or less serious results. In the days when a cargo boat of some 5,000 tons deadweight was considered a large vessel, little was heard of longitudinal weakness. Conditions, however, have rapidly changed, and a cargo boat nowadays of 10,000 tons

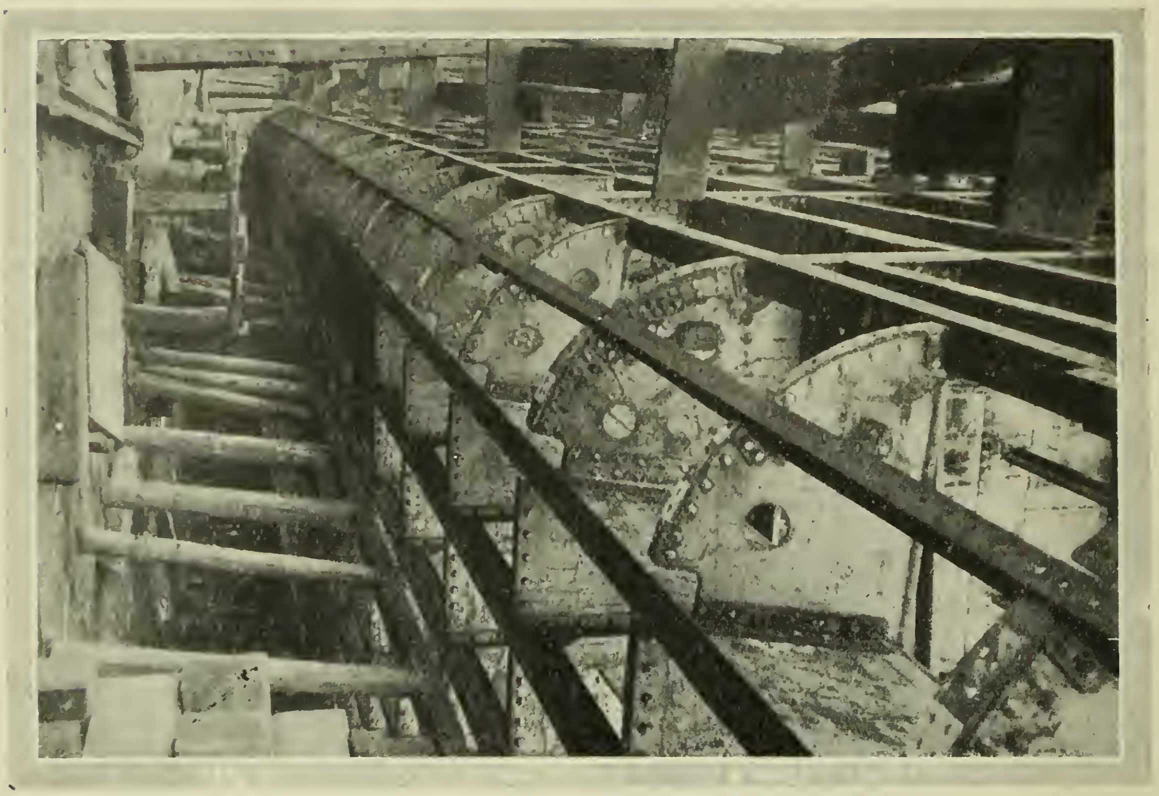


Fig. 65. Internal View of a Tank Steamer built on the Isherwood system.

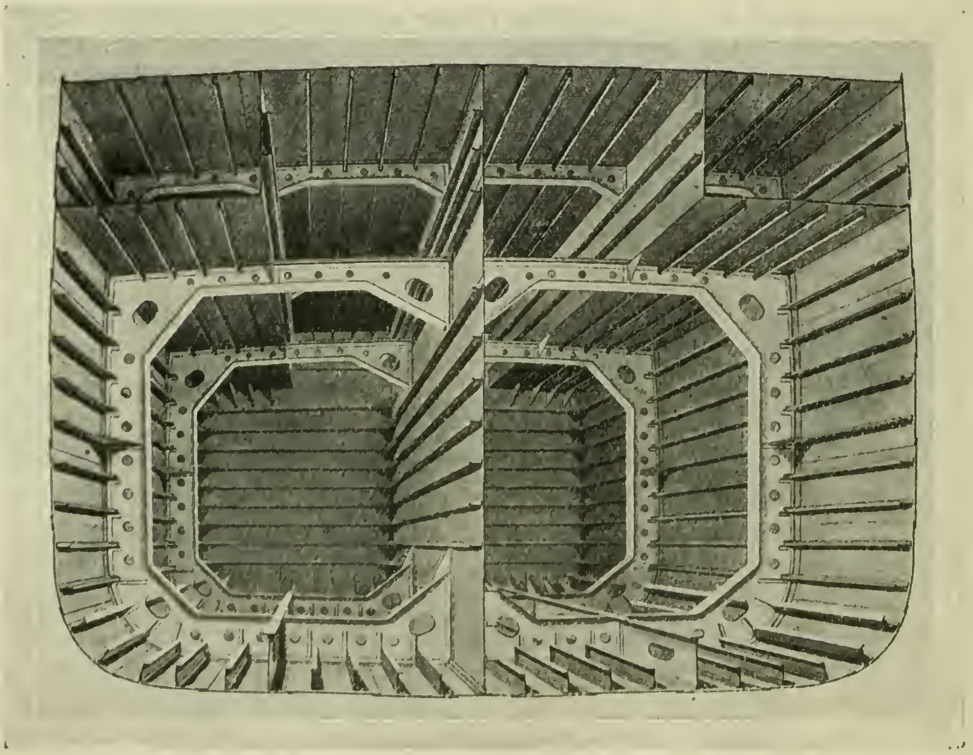


Fig. 66. Bilge Construction of a vessel built on the Isherwood system.

deadweight is commonplace, and does not call for any special comment. Proportionately, the large boat of to-day is not of equivalent strength to the small boat of twenty years ago or so, though the large boat has to comply with more exacting conditions.

In J. W. Isherwood's system of ship construction the transverse frames and beams are fixed at about six times the usual distance apart—*i.e.*, at 12 ft. intervals, and are slotted around their outer edges in order to admit of continuous longitudinal stiffeners being fitted, not only at the decks, but on the sides, bottom, and tank top.

The fitting of these longitudinal stiffeners directly on to the plating prevents damage to the decks through buckling, which has frequently occurred in vessels of the ordinary construction which have had no fore and aft support to the plating in between the transverse beams. This longitudinal method of framing, lending itself to a correct distribution of materials, gives a vessel incomparably superior to the old-fashioned transverse type.

The great drawback of ordinary transverse vessels has always been a serious lack of strength in a longitudinal direction. The strong transverses fitted at a wide distance apart in the " Isherwood " system provide more than sufficient transverse strength, and the continuous longitudinals give a proper amount of longitudinal strength. From the strength point of view alone an " Isherwood " vessel is much superior to a transverse vessel, and this advantage claimed on theoretical grounds has been substantiated by actual experience.

The " Isherwood " system—which is a radical departure from the rules that have governed shipbuilding for so long—has already proved to be quite suitable for every type of vessel constructed on it; the fact that 960 vessels of 7,666,000 tons have been built, or are on order, on this system shows conclusively, and in the best possible manner, that a longitudinal system of strengthening vessels is both theoretically and practically sound.

The Isherwood vessels range in size and type from light scantling, light draft inland water, passenger vessels of 134 ft. in length up to the fine River Plate passenger and cargo liner, *Vestris* 500 ft. long, and larger vessels now under construction for the U.S.A. Shipping Board; from oil barges 80 ft. long to the largest oil-carrying vessels ever built—namely, of 16,000 tons deadweight carrying capacity—and oil tank vessels of 18,000 tons deadweight carrying capacity are under construction. The system has been used for small colliers up to the largest colliers in the world, for the large ore carriers used on the Great Lakes of America and Canada, and for that leviathan of grain carriers the *W. Grant Morden*, 604 ft. in length, built at Port Arthur, Lake Superior, Canada.

The experience gained with the Isherwood all-steel system is of great value to those who are considering the construction of concrete ships, because, as will be seen later, the latter are largely based on the same underlying principles—*viz.*, the arrangement of the strength-giving members in longitudinal and transverse directions in such proportions as will best meet the stresses to which the vessels will be subjected.

The success of the Isherwood system for steel vessels is important in connection with concrete ships, as it has proved the soundness of the use of longitudinal strength-giving members upon which the designers of concrete vessels necessarily rely.

The interior of a large steel vessel is divided into compartments by partitions known as *bulkheads*, which strengthen the structure and also serve to isolate any portion of the shell which may have been damaged and so permits water to enter the vessel.

As is well known, the keel is placed longitudinally below the centre of the bottom of the vessel, and two small keels, known as bilge keels, are fitted on each side of the vessel. These bilge keels only extend along the broader part of the vessel for about one-third—more or less—of her length. Their use is to prevent the ship from rolling too much from side to side in a rough sea. Extending from the keel in the middle of the vessel as far as the bilge on either side there is a hollow space divided into many small compartments. Above these compartments is placed the inner bottom. There are two advantages in giving a vessel this double bottom.

In the first place it increases the safety of the ship. Should she strike on a rock and have a hole made in her outer plating, she will still float if the inner bottom is not damaged. The water will not penetrate beyond the space between the two.

Then, too, the compartments between the two bottoms can be used as tanks to hold water. This water answers the purpose of " ballast "—a weight placed in the bottom of a ship to keep her from being top heavy and to make her float steadily.

The foregoing terms are all shown in *Fig.* 64, which is inserted for the benefit of those who are unfamiliar with them.

The bow of a vessel must be very strong, for one of the most frequent accidents at sea is a collision. The stern frame must also be very strong, as when a vessel pitches the stern, with its heavy rudder and rapidly revolving propeller, may be lifted quite out of the water, and after a time it may drop down again as suddenly as it was raised.

Every seagoing ship must be designed and built to resist the very powerful forces of winds and waves. Sometimes the waves driven by the wind will meet her right in front ; sometimes they will strike full upon one side as she passes on her course, or they meet her in a slanting direction ; at other times they will follow, overtake, and dash against her stern.

All these possibilities and many others must be considered when a ship is designed. Her sides must be strong in order to resist a direct blow ; her framing must be stiff, or else, when heavy waves strike her slantingly, she will be liable to twist in shape. Her weight must be carefully calculated and so arranged that she will not only float perfectly upright in a calm sea, but, when she is rolled partly over by a wave, she may always " right herself "—come to an upright position again.

A small boat sailing in a rough sea rides over the crest of a wave, down into the trough and up on the next wave, but when a large ship is travelling through such waves her bow may be upon one wave while her stern is raised upon another. In such a case part of the vessel will be in the trough between two waves, and if the waves are exceptionally high and the troughs between them very deep, it may be hanging almost without support in the deep trough, while her ends are supported on the crests of waves. This vessel is then said to be in a *sagging* condition.

Alternatively, the vessel may be supported only in the middle, the greater part of her being out of the water in what is known as a *hogging* condition. In the sagging condition the bottom members of the structure will be in tension and the top members in compression, and in the hogging condition *vice versa*.

In either case, a weakly constructed vessel would be almost certain to break in two. Consequently, whilst vessels for use solely on canals and moderately sized rivers or on very smooth lakes need only be provided with means for resisting ordinary hydrostatic pressures (except where they have to ground on an uneven bottom) and the shocks and stresses due to coming in contact with other vessels, quay walls, etc., sea-going vessels must resist the dynamic forces due to mooring, berthing, docking, etc., as well as sagging, hogging, and torsional strains when striking a wave or falling in a heavy sea.

The bending and hogging strains due to wave conditions can be readily calculated, but the torsional and racking strains cannot. In shallow-draught and river vessels, having as a rule only the strains due to unequal loading, grounding, etc., the scantlings may be lighter than in sea-going vessels.

The amount of local strength required in various parts of a vessel is not amenable to calculation, and the only safe way of deciding how it shall be provided in reinforced concrete vessels appears to be to use the experience gained with steel and wooden vessels, and to give the same amount of local strength to a reinforced concrete ship as in a steel ship of the same size.

Another important difference between sea-going vessels and structures on land is due to the fact that whilst the forces acting on the latter may act in various directions, yet the direction of each force is maintained constant, and if any change occurs it does so very slowly.

With a vessel in a seaway, however, the stresses are constantly changing in value and also in direction. A member may be in tension at one moment and in compression shortly afterwards, and so on. Such changes of stresses produce " fatigue," the deformation produced by equal increments of stress being at first nearly constant, but gradually increasing and becoming rapidly greater as the point of rupture is approached. For this reason, some authorities consider that the maximum compressive stress allowed in the concrete in a ship should be less than that used in land work, more steel being introduced than is generally allowed by most designers.

Although the forces set up in a collision cannot be calculated beforehand, there is no difficulty in designing concrete vessels which will resist an impact as well as any steel vessel, and better than wooden ones.

In making these calculations for reinforced concrete, it is necessary to know the modulus of elasticity for concrete and steel, and the ratio as used in combination, because, while the modulus of steel is fairly constant up to the yield-point, the moduli of concrete vary with the quality of the concrete and the stress upon it, being greatly reduced as the stress increases, so that the ratio of the moduli of elasticity used for determining the position of the neutral axis and the other properties of a section of a beam is not the ratio which exists between the initial moduli of elasticity of the two materials As the modulus of the concrete varies to some extent with the amount of its immersion in water it is possible that the ordinary modular ratio of 1 : 15 used for land structures may not be at all appropriate for ships, especially having regard to the richer mixture of concrete and the greater factor of safety (=6) usually considered to be necessary.

Considering the hull as a beam, the bending moments are calculated on the assumptions found in the text-books. As the hogging bending moment is usually greater than that in the sagging condition, the amount of reinforcing steel at the deck will be greater than that in the bottom. The reduction of resisting moment at the ends consonant with the decline of the bending moment is effected by the gradual elimination of a suitable number of longitudinal rods.

The stresses set up by a shearing force are resisted by rods placed at an angle of 45 degrees to the top and bottom faces, the number of rods used in a given distance being proportional to the shearing stress. It is often convenient to replace these diagonal rods by stirrups, which also prevent the reinforcement from buckling under load. At the quarter lengths of the ship the shearing forces are at a maximum and require additional reinforcement. This is sometimes provided by bending up some of the longitudinal rods which are not required to carry tensile loads. The arrangement of these diagonal pieces, stirrups, etc., constitute the essential features of various systems of concrete construction. Whilst each of these systems usually has some advantage over others, no definite means has yet been formed whereby all points, including economy, may be considered and balanced against each other. Consequently, it is very difficult for an engineer or architect who has not specialised in reinforced concrete to determine the relative merits of various systems.

The generally accepted method of reinforcement consists in the insertion of thin horizontal bars or rods and strips of steel in just those places, and in those places alone, where the resistance of the concrete requires to be supplemented in order that it may withstand tensile stresses. These bars may be bent at each end so as to provide an increased resistance to the shearing force supplied by the load, or they may be fitted with " shearing members " in the shape of attached bars, loops, stirrups, etc. The shape of these attachments and of the bars themselves is the subject of various proprietary rights, and forms the chief distinction between the different " systems " of reinforced concrete.

These shear members are necessarily of short length, since they are limited by the depth of the beam itself, which, as a rule, does not exceed one or two feet.

It is therefore essential that these " shear members " should be rigidly attached to the main tensional members, and it is also of great importance that a good mechanical bond should exist between the steel and the concrete along the shear bars. For this reason, the R.I.B.A. Committee Rules stipulate that: " As the resistance of the shear members to the pull depends on the adhesion and the anchorage at the ends, it is desirable to use bars of a small diameter, and to anchor the stirrups at both their ends." If a smooth bar is bent up as a shear bar the adhesion of the concrete to the short length of steel available is insufficient to develop the full strength of the metal before the latter will pull out of the concrete. A large proportion of the metal in the shear bars is thus wasted, and to obtain the requisite strength far more steel has to be provided than is actually necessary. If, however, indented bars are used the full strength of the steel is brought into action. Some of the main torsional members can themselves be bent up towards the ends of the beam into the correct position for taking the shearing stresses. These " shear members " are not merely connected rigidly to the main bars, but are actual portions of the same bars, the anchorage extending throughout their length.

The L.C.C. rules refer to this property of indented bars when they demand that all shear bars shall have a " mechanical anchorage at both ends, or they shall have a mechanical bond with the concrete throughout their length."

In ordinary commercial round or square bars small sections are generally favoured, as they give a larger proportionate surface for adhesion, and are more easily manipulated. Hoops, bands, and flats of small section are used, but rounds and squares are the sections generally employed in reinforced concrete work.

The permissible working stresses for the concrete will depend on the materials used. The upper and lower limits for the modulus of elasticity of concrete are usually taken as 2,000,000 and 3,000,000 lb. per sq. in. respectively. The direct compressive working stress will be about 730 lb. per sq. in., and the shearing stress one-tenth of this figure. The tensile strength of the concrete, apart from the reinforcement, is so low that it is customarily regarded as zero.

The effects of sudden reversals of stress may be much more serious in concrete vessels than in those made of steel. These effects are quite incalculable, and can only be learned by experience. They may be kept at a minimum by carefully arranging the reinforcement so as to resist all tension stresses applied, without any extension of the steel greater than can be followed by the concrete.

There is a widespread opinion among naval architects and seafaring men generally that a concrete ship will be so inelastic that she will tear herself to pieces in a sea. Experience with other reinforced concrete structures has shown, however, that such

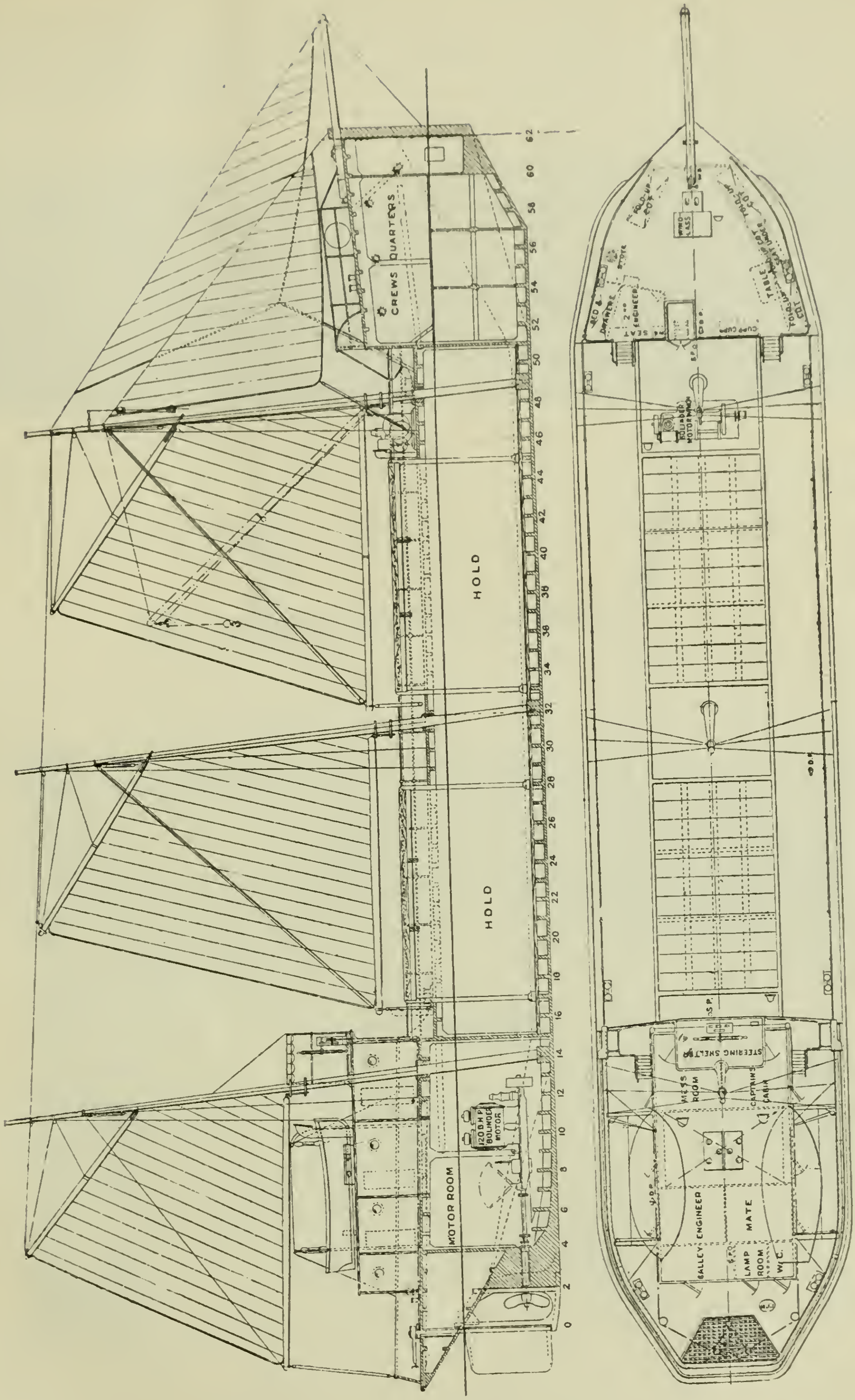


Fig. 67. General arrangement of a Concrete Coaster by Pollock.

structures have considerable elasticity, and there is ample reason to hope that reinforced concrete will prove sufficiently elastic for shipbuilding purposes.

Briefly, then, concrete vessels should at present be designed on lines similar to those of a steel ship, and using similar fundamental calculations, but modifying both these and the design so as to gain the maximum advantage derivable from the use of the reinforced concrete.

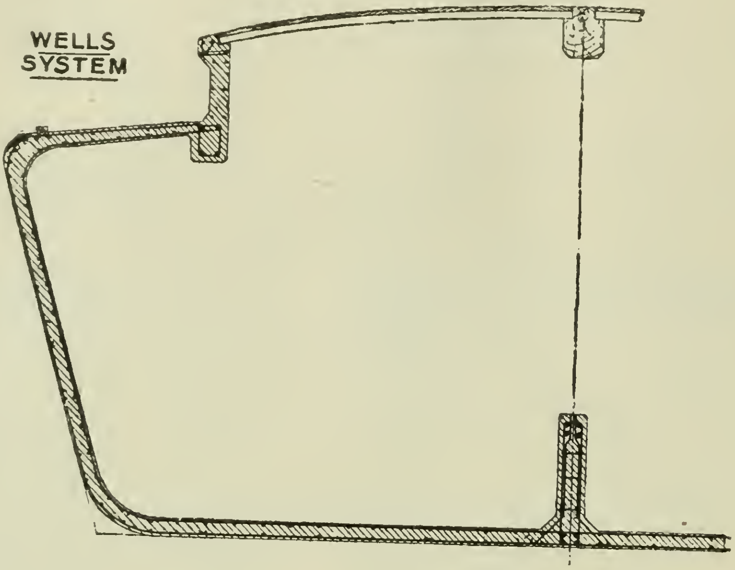


Fig. 68. Midship Section of a Concrete Swim Barge.

Mr Pollock's ideal design is a vessel with longitudinal construction, with only a few web frames and as many bulkheads as possible, and a series of diagonal rods in addition to the usual longitudinal ones. In large vessels it would be advisable to fit a centre bulkhead for the full length of the ship, and all cargo vessels should have the hatch coamings continuous all fore and aft, as shown in *Fig.* 67. In small vessels, barges, etc., a slab form of construction (*Fig.* 68) is economical, as it dispenses entirely with floors and frames, side keelsons, stringers, beams, etc., and can be rapidly completed. A continuous carling, even if it projects 6 in. above the deck, is desirable.

MEMORANDA.

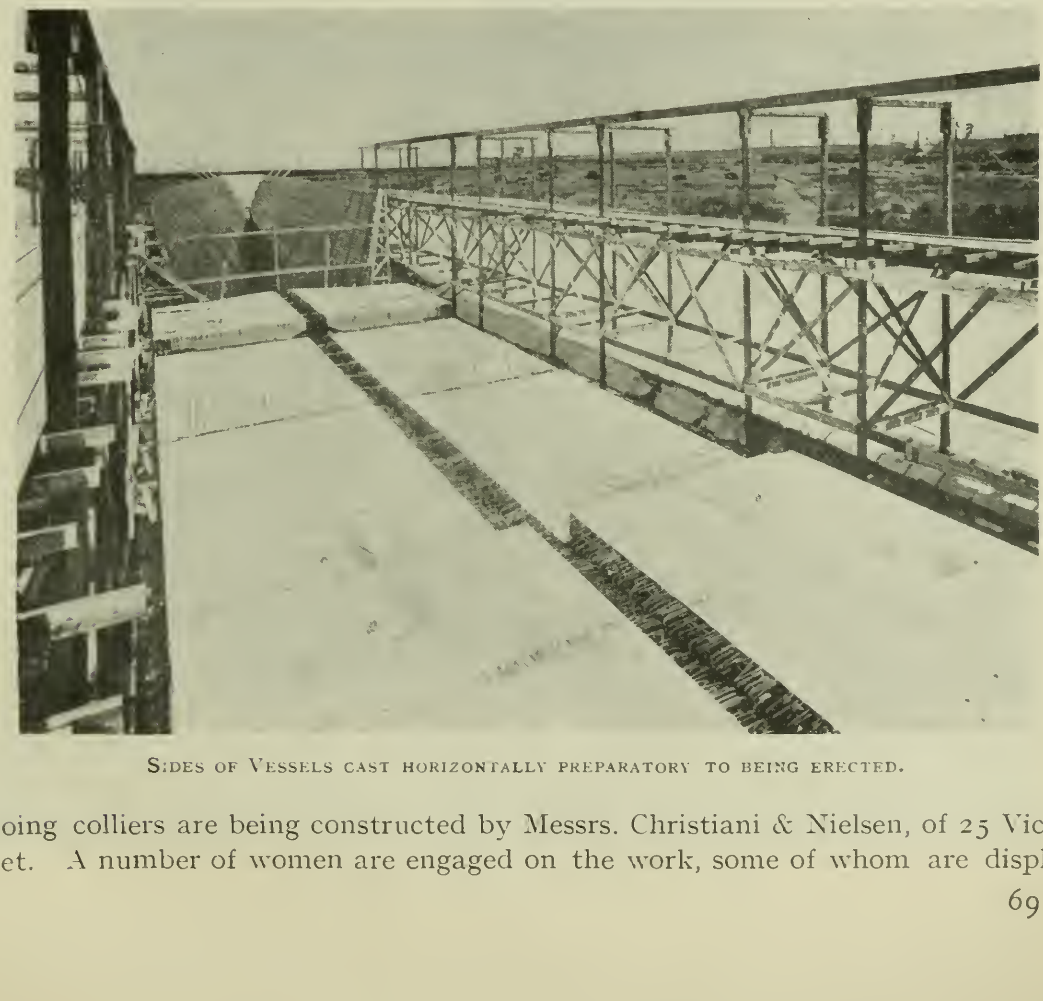
Concrete Oil Tanker.—A 1,000-ton sea-going concrete oil tanker was launched at the end of January at Poole. This oil tanker is 190 ft. between perpendiculars, by 33 ft. beam, by 15 ft. 6 in. deep, and has been built to the order of the Controller-General of Merchant Shipbuilding, who has supplied the general arrangement drawings and specifications to which the vessel was built. It will carry 800 tons of oil on a 12-ft. draft and 1,000 tons on a 13-ft. 8-in. draft. The detailed designs were prepared under the direction of Mr. E. O. Williams, B.Sc., A.M.I.C.E., and the vessel was built by Messrs. Hill, Richards & Co., Ltd., to the survey of the British Corporation Registry of Shipping.

Concrete Ships, U.S.A.—A 3,000-ton concrete freighter, the *Atlantus*, was launched at Brunswick, Ga., on December 4th. The vessel was built under the direction of the Emergency Fleet Corporation by the Liberty Shipbuilding Co. In this ship the new burned clay light aggregate developed by the U.S.A. Government was used. This aggregate is said to give a concrete weighing 110 lb. per cu. ft.

SITE OF DOCKYARD AT TILBURY AT END OF MARCH, 1918.

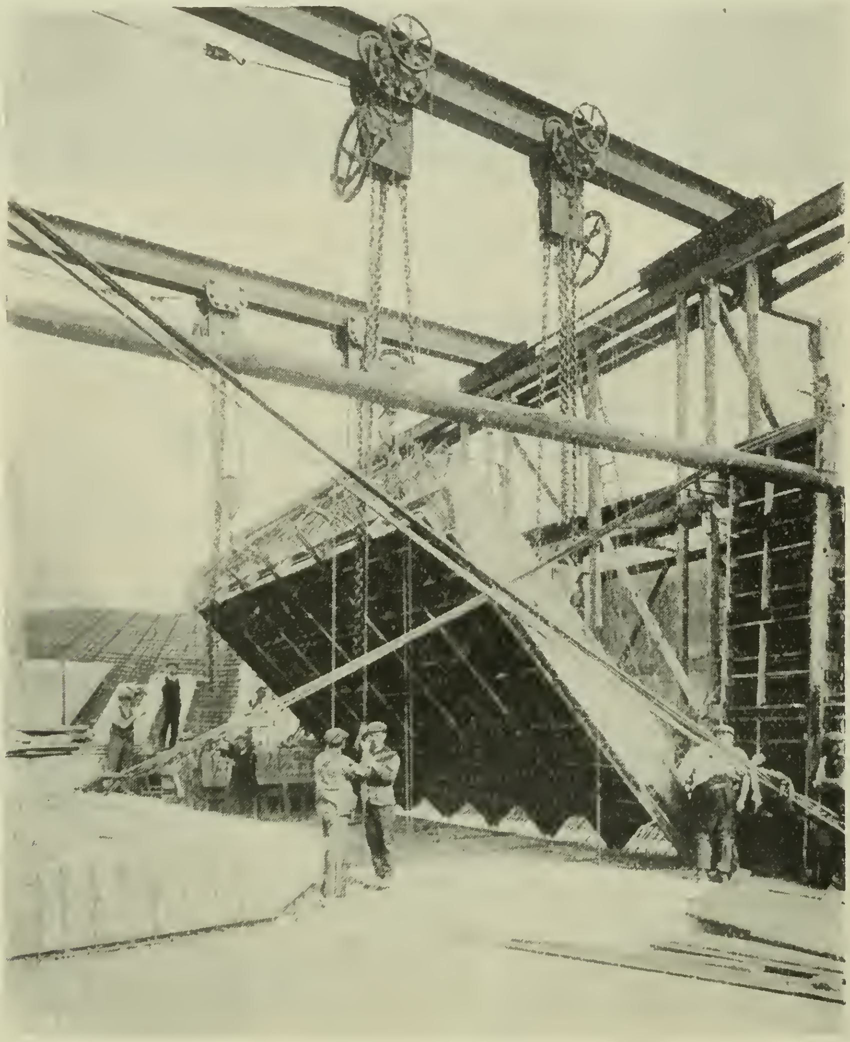
REINFORCED CONCRETE SHIPBUILDING AT TILBURY.

DURING a recent visit to Tilbury we had an opportunity of visiting a new yard which is being constructed, and in which five of a set of ten 1,000-ton reinforced concrete seagoing colliers are being constructed by Messrs. Christiani & Nielsen, of 25 Victoria Street. A number of women are engaged on the work, some of whom are displaced



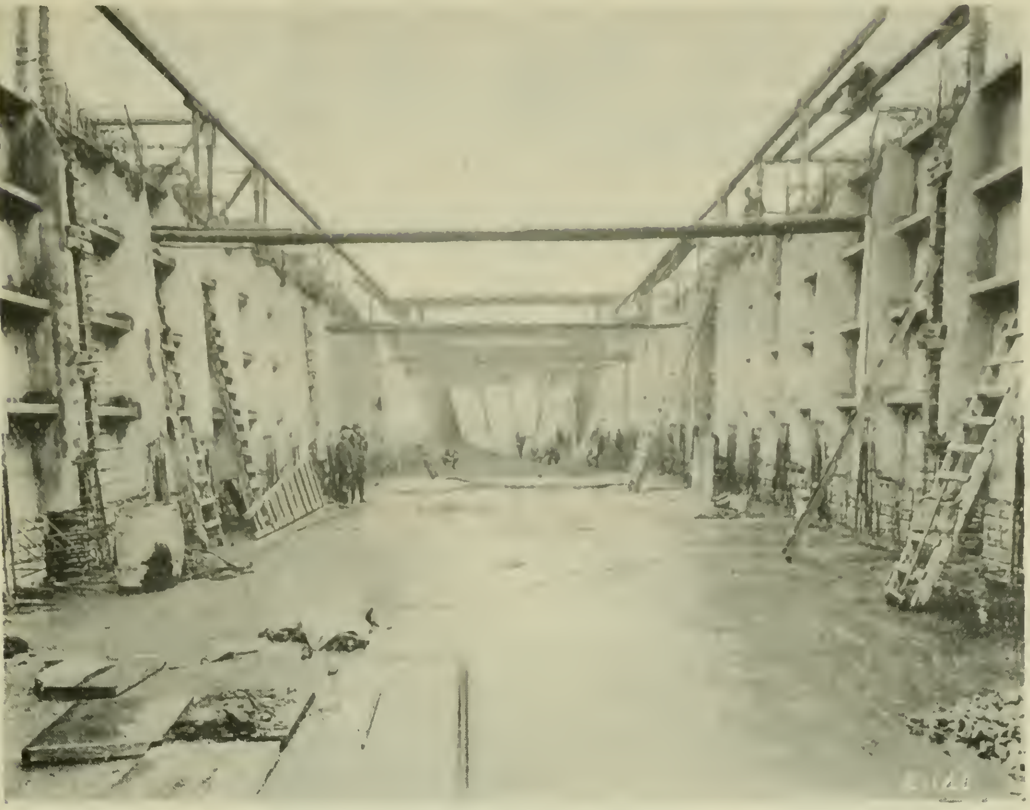
SIDES OF VESSELS CAST HORIZONTALLY PREPARATORY TO BEING ERECTED.

munitioneers, and they have been employed in consequence of the shortage of men, though men carry out certain parts of the work. In March last year the site was a piece of waste land, but this has been converted into a shipbuilding yard consisting of a dry dock for building the vessels, accommodation for plant, material and work-people, while a lock with gates of reinforced concrete has also been provided. The laying out of the yard, including the dock walls and the dock gates, was completed by the end of the year, and while this work has been carried out the ships have been building, and these are ready for launching at the same time as the yard is completed.

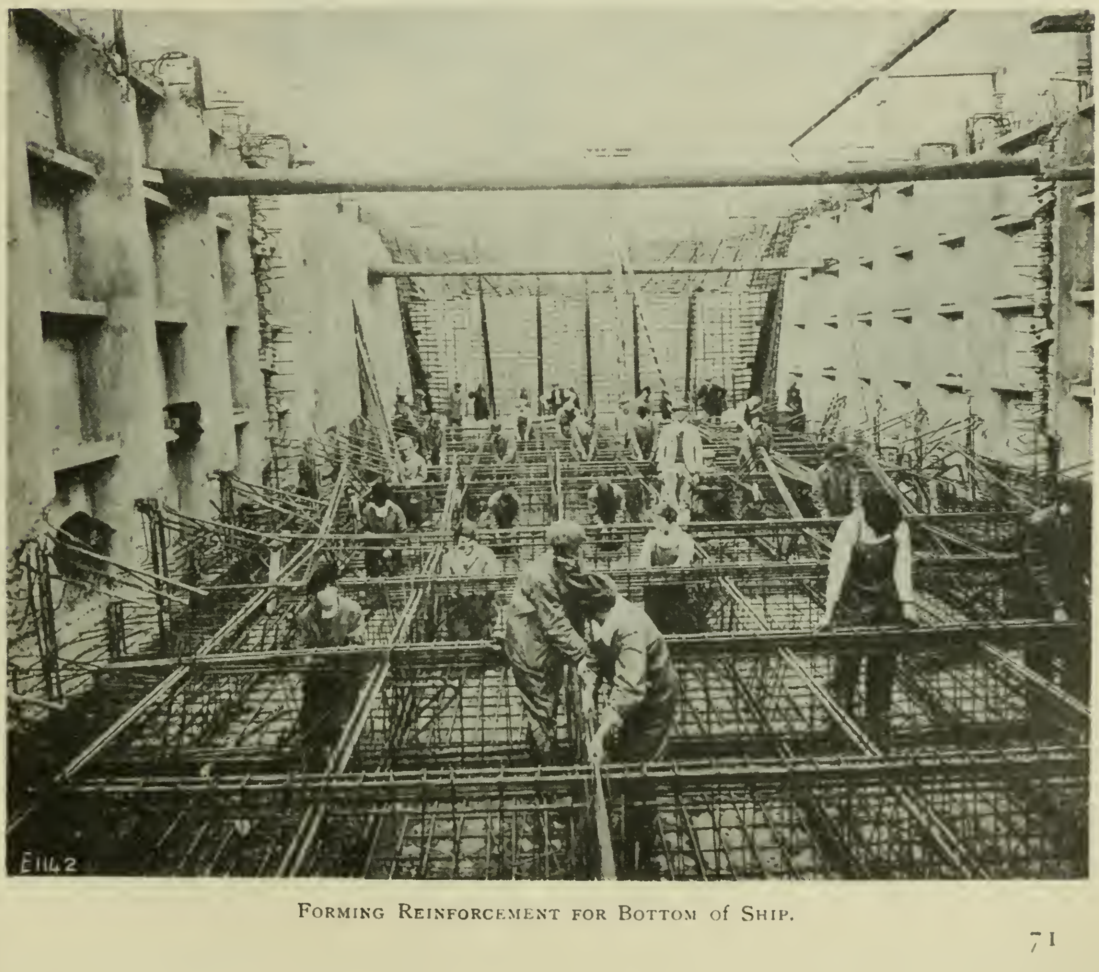


ERECTING THE SIDES. EACH SLAB WEIGHS ABOUT 50,000 LB., AND IS ERECTED IN AN HOUR.

The system employed in building the ships has been patented by Mr. R. N. Stroyer, chief engineer and manager of the firm, and provides for the use of large pre-cast units for the sides of the vessels, As will be seen from the illustrations we give, the sides are cast horizontally on the floor of the dock, their dimensions being determined by the size and internal arrangements of the ships, inasmuch as the joints are made to coincide with the bulkheads and are subsequently raised by suitable lifting tackle and put in position. A part of the bow and stern is cast in position in the ordinary way, as the curves do not easily admit of the use of the method employed in casting the sides. Having been cast in two rows in the necessary



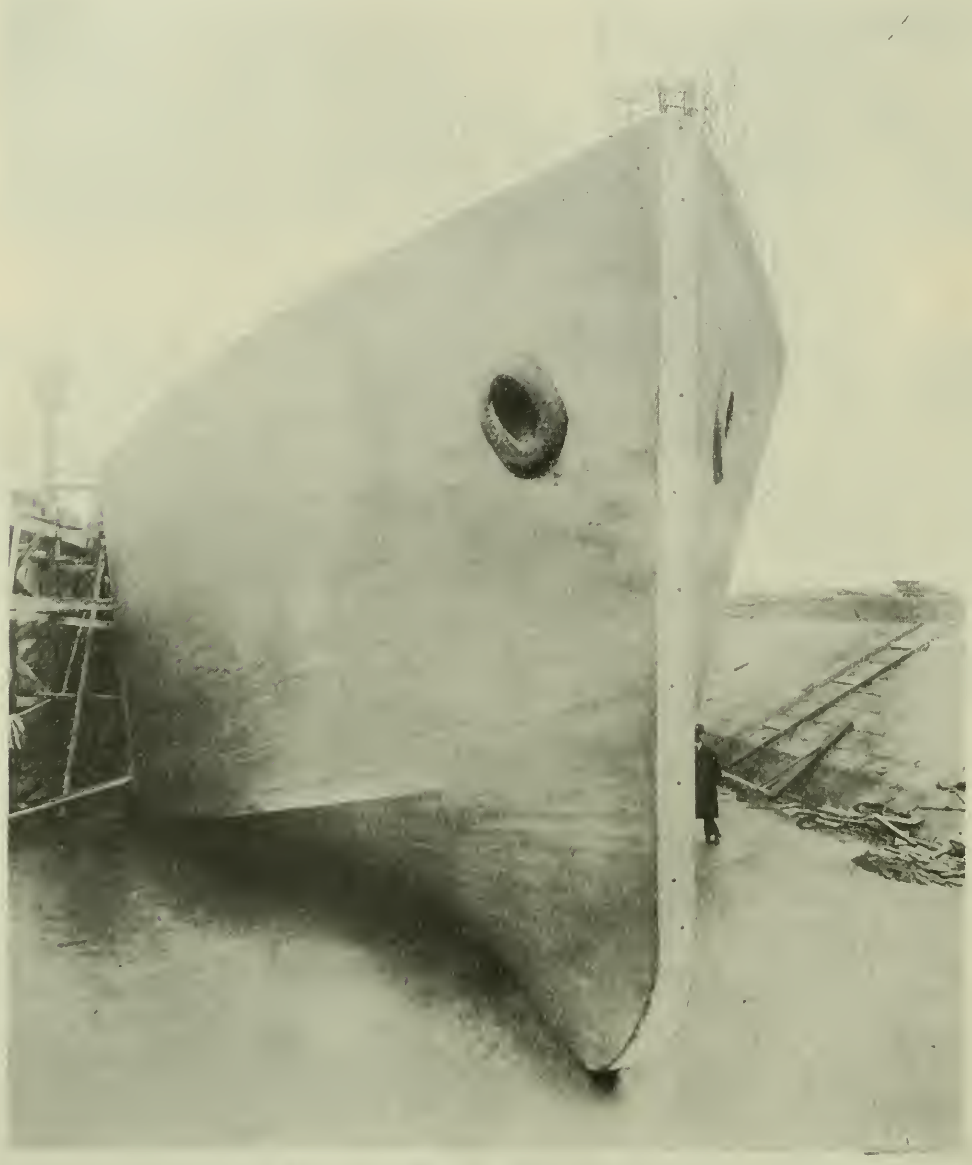
Sides erected on the Dock Floor, which forms shuttering for Bottom of Ship



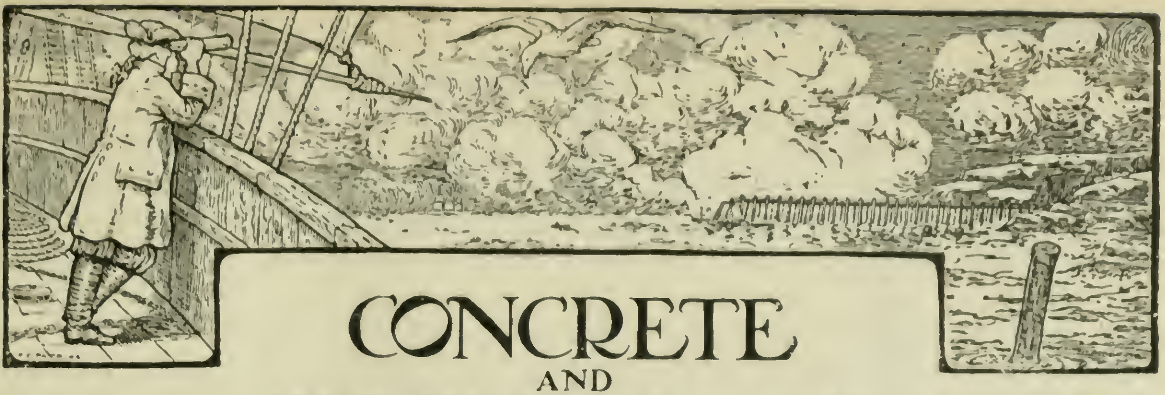
Forming Reinforcement for Bottom of Ship.

position, the blocks forming the sides are raised and joined together, the projecting steel reinforcing rods being turned and interlocked and then filled with concrete. The method of casting the sides is an easy and economical one, and the work from beginning to end appears to have been carried out without any special difficulty. After the sides have been erected, the steel rods for the reinforcement of the bottom of the ships are put in position and subsequently filled in with concrete, which rests on tarred paper. The transverse bulkheads are formed at the junction of the side units, and every precaution is taken to make each joint as sound as possible. The saving in labour and material for shuttering has been very considerable, and has reduced the cost and time of construction.

Although the ships had not been completed when we were at Tilbury, rapid progress was being made with them in the hope of completing them by the end of 1918, and this, we understand, would constitute a record in concrete shipbuilding in this country having regard to the fact that on an average only 250 employees have been working during the year.



BOW OF A VESSEL NEARING COMPLETION.



CONCRETE
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"CONCRETE SHIPBUILDING"

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REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER IV (*continued*).

DESIGNING CONCRETE VESSELS.

It is not difficult to design a reinforced concrete vessel with a graceful form, nice curved lines, and a handsome sheer, but expense is involved in fixing and in keeping the steel reinforcement in place during moulding and casting, and if the steel reinforcement is not kept in proper position both vertically and horizontally a considerable amount of strength of the structure will be sacrificed, and as it is almost impossible to keep all the steelwork in a 3-in. slab curved vertically, horizontally, and diagonally, as in the case on the bow of an ordinary ship-shape vessel, in its proper position with a deviation of under ¼ in., it is preferable to modify the lines of the vessel to overcome this difficulty. Furthermore, if the steel rods be not true to line they tend to straighten out when subject to a tensile pull, and so cause the concrete to burst off, besides reducing their effectiveness through the introduction of secondary stresses. The hatch coaming should have a strong top and rest bar to avoid damage (*Fig.* 69).

To overcome these difficulties, it is customary to design all but the smallest vessels with as few curves as possible, so that the greater part of the reinforcement may be arranged in straight lines. The minimum amount of shaping would be given by a rectangular box, but this form would offer too much resistance to passage through the water on account of its square ends. Between this and the customary shapes of vessels there is scope for much ingenuity. Two " straight frame forms " suggested

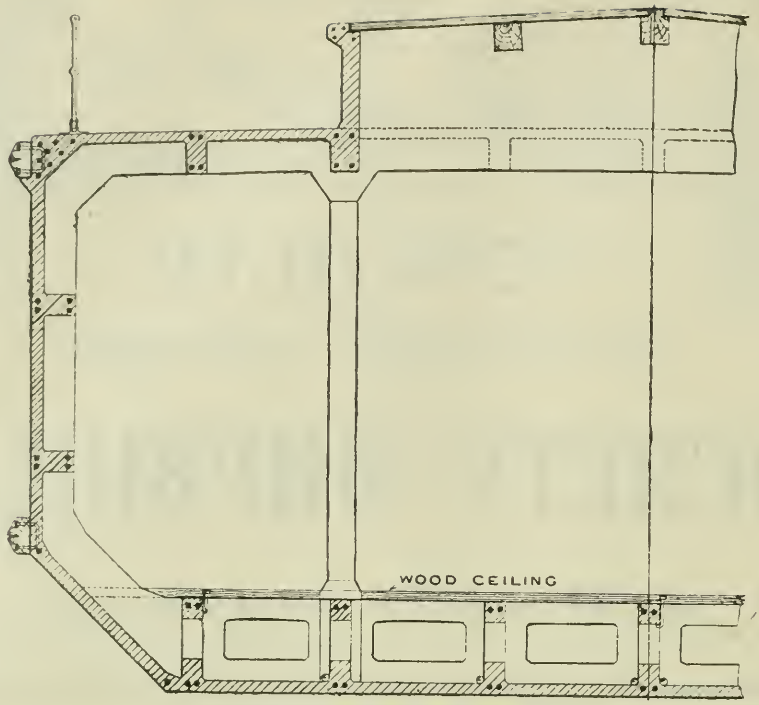
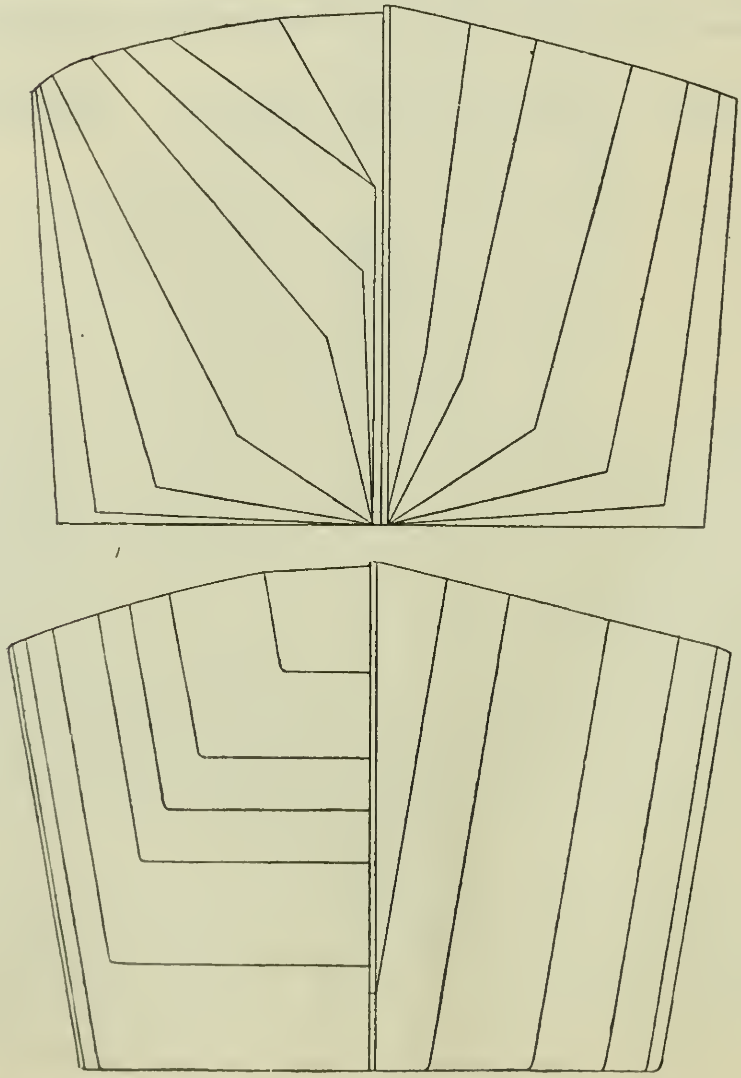


Fig. 69. Midship Section of a 500-ton Coaster.



Figs. 70 & 71. Two Straight Frame Forms suggested by M. Denny.

by M. Denny are shown in *Figs.* 70 *and* 71, the former being designed to suffer a minimum of damage on impact and the latter to secure " flare " at the bows. Another straight frame form, designed by W. Pollock, is shown in *Fig.* 72, and others will be seen on glancing through the illustrations in the present chapter. Certain minor disadvantages accompany this change of shape, but they are far outweighed by the advantages gained.

In order to protect concrete vessels from unnecessary damage by impact and abrasion, they should be fitted with wooden or other fenders, but in some barges they have been entirely dispensed with, the corners of the gunwale being well rounded so as to avoid being chipped when coming in contact with or striking other vessels. A solid half-round for the gunwale, as shown in *Fig.* 68, and other chafing irons are desirable. It is, however, advisable to fit fenders to all concrete vessels as a precautionary measure, as concrete subjected to considerable rubbing or chafing will soon wear away. All edges or corners throughout the vessel should be rounded or bevelled where possible to prevent being chipped or broken off.

It is probable that when more experience and additional experimental data are available it will be better to design concrete vessels with a closer relationship to first principles and to pay less regard to the conventions of steel ships. For instance, a large allowance is made for the corrosion of the steel in a steel vessel, and this has the indirect effect of making it appear necessary to build vessels to resist much greater pressures and other stresses than will ever be experienced. Meanwhile, the co-operation of men of experience in concrete work and in shipbuilding respectively may be expected to result in considerable advances in the construction of concrete vessels.

Professor Suenson, of Copenhagen, maintains that it is not reasonable to insist that the strength of concrete shall be based on data which have been found satisfactory for steel vessels, as the latter are subject to rusting and other factors which have been taken into account when designing them, but which have no bearing on vessels made of concrete. Thus, the longitudinal strength of a vessel is based on the assumption that its main trochoid has an axial height of $L \div 20$.

The crosswise strength of vessels is based on the assumption that the whole load may be stowed in only one half of the hold. The base, side walls and deck are often designed without much regard for static considerations, as there are so many influences exerted on vessels when afloat which render rigid static calculations unnecessary.

In barges and other vessels without decks it is usually assumed that the bottom and sides form a double-linked framework with a horizontal shearing stress (H).

$$H = \frac{qb}{4h}\left(\frac{b}{3+2\frac{s}{b}} + 2a\right)$$

where q is the greatest outwards water pressure less the total load distributed over half the length of the vessel. The latter is taken in two separate cases : (1) where the load is placed uniformly in the centre of the vessel ; (2) where the load is placed between the centre and end of the hold.

b is the width at the bottom of the vessel.

h is the height of the vessel.

a is half the difference between the width at top and bottom of the vessel.

s is the sloping height (measured along the side).

In the vessels with deck-supporting bearers it is assumed that the latter form a double linked frame with the sides. In this case :

$$H = \frac{pl}{4h}\left(\frac{l}{3+\frac{2s}{l}} - 2a\right)$$

where p is the load or weight unit length of deck.

l is the width of the deck.

a is the difference between the greatest and smallest widths of the vessel.

s is the sloping height of the vessel.

Sea-going vessels more than 120 ft. in length require to be made much stronger (up to double the bending moments) than those for inland water.

Following the foregoing considerations, designers of concrete boats have reached certain general conclusions, of which the most important are :

(*a*) The *shape* of the hull must be similar to that approved as the best for steel or wooden ships used for similar purposes, though the concrete vessels may be built deeper so as to enable them to carry the same load as steel vessels of the same length and beam. A considerable saving in the cost of construction may be effected by replacing the curves of barges and other craft with a speed of less than 9 knots by straight lines as far as possible. The manner in which this has been accomplished is shown in the succeeding illustrations.

(*b*) The *size* of concrete vessels appears to be unlimited ; the largest yet built (the *Faith*) has a capacity of 5,000 tons. The principal dimensions of existing concrete vessels of various kinds are shown in Table II.

(*c*) The *proportion of reinforcement to concrete* requires careful study. Apparently in the vessels constructed hitherto there has been an unnecessarily large amount of reinforcement used, the builders naturally preferring to secure safety by using an excess of steel rather than to risk loss of life by employing a much smaller proportion of this metal. In concrete structures on land, the relative weights of reinforcement and concrete are about 3·3 : 100, but in concrete vessels the ratio is nearly 13 : 100, and steadily increases with the size of the vessel.

M. Denny has found that the average figures for percentage weight of steel to total weight of reinforced concrete are for an existing 500-ton barge 11 per cent., for a 1,000-ton barge 14 per cent., for a 6,000-ton steamer 22 per cent. This last figure corresponds to a percentage area of steel to reinforced concrete of about 7 per cent., whereas for structures on land the area is only 1 per cent.

(*d*) The *thickness of the concrete* should also be investigated. It is obvious that there must be a certain " cover " round the reinforcement, and that this must be sufficiently thick to withstand the pressure applied to the spaces between the reinforcing members Further considerations show that the minimum thickness is about 2 in. for vessels of large size and 1½ in. for smaller vessels. The thickness of the concrete in various existing vessels is shown in Table II

TABLE II. TYPICAL SIZES OF CONCRETE VESSELS.

Type.	Builder, etc.	Length.	Breadth.	Depth.	Draught (empty).	Dead-wgt. Capacity (tons).	Thickness of Walls.
Rowing boat	J. Bowman, Montrose ..	12′	4⅓′	2¾′	—	—	—
Motor boat	German	14½′	5⅓′	—	2¼′	—	½″
Motor boat	Dowsey	18½′	4½	—	—	—	¾″
Motor launch ..	Muribloc, Ltd.	21′	5¼′	3′	14″	—	⅝″
Lighter	Boon	47′	10′	7′	—	15	1¼″
Barge	O. F. Lackey	50′	22′	10′	—	—	3″
Barge..	Oest. Eisenbeton-Schiffbau-Unternehmen	58′	20′		—	150	3¼″
Barge..	Boon	62′	14′ (top) 11′ (bottom)	—	—	50	2″
Barge..	Boon	63′	15¾′ (above water) 12⅓′ (below water)	4⅓′	18″	—	—

TABLE II (*cont.*). TYPICAL SIZES OF CONCRETE VESSELS.

Type.	Builder, etc.	Length.	Breadth.	Depth.	Draught (empty.)	Dead-wgt. Capacity (tons).	Thickness of Walls.
Barge	Cement Ijzer Werken Holland	64′	14′	—	—	55	2″
Lighter	—	68′	15′ (above) 12′ (below)	—	—	—	1¼″
Barge (monkey) ..	Guest, Stourbridge ..	70′	7′	4′	14″	27	—
Barge..	For use on Welland Canal	80′	24′	7′	—	—	2½″
Barge..	Société Pelnard-Considère, Caquot et Cie.	83′	17′	7′	—	—	—
Barge..	Bahia (Coignet) ..	83′	19′	6½′	—	1,620 cu.ft.	—
Barge..	—	85′	21′	8′	—	70	1¼″-1½″
Barge..	Taylor Engineering Co...	105′	32′	16′	8½′ (loaded)	500	—
Barge (for sand and gravel)	Baltimore, Arundel Sand and Gravel Co., built by Furst Concrete-Iron Construction Co.	112′	29′	10′ (hold)	4¾′	500	4″
Barge..	Louis L. Brown Co., New York	112′	33′	10′	—	700	—
Barge..	Bahia (Coignet) ..	119′	22′	9′	—	9,000 cu.ft.	1·6″
Barge..	Allen Hoare	120′	28′	8′	2′ 7″	400 tons	—
Barge..	Bahia (Coignet) ..	125′	22′	4′	—	120	—
Lighter	Allgemeine Verbundbaugesellschaft, Frankfort-on-Main	130′	20′	—	13′	220	—
Barge..	Fougner, Norway ..	145′	—	—	—	600	—
Barge (towing sea-going)	J. & W. Stewart ..	150′	24½′	13½′	11′	400	—
Barge..	Lorton	150′	26′	—	2′	700	1·6″
Barge..	Roux	152′	26′	12½′ (hold)	10′	450	2·4″
Barge..	Hennebique	185′	34′	19′ (hold)	9′	1,000	4″
Barge	U.S.A. Joint C.C. ..	227 (between pprs.)	42′	23′	18′ (loaded)	2,000	3″
Motor cargo boat	Holland, Hannen & Cubitts, Ltd., Chiswick	40′	8½′	4½′	4′	—	—
Motor cruiser ..	Savin Hill, Dorchester, Mass.	41′	8′ (11′ at waterline)	—	—	—	1½″ at keel, ⅞″ gunwale
Motor coasting vessel	Pollock	92′	19′	10′	—	—	—
Motor cargo boat ..	—	98′	19½′	10′ 7″	—	200	—
Motor cargo boat ..	Spain	113′	24′	11½′	—	450	—
Single-screw steamer	Atlas Construction Co., Montreal	125′	22′	13′	—	—	3″-5″
Motor transport ..	Pollock	125′	25′	11½′	9′ 9″ (loaded)	300	—
Motor cargo boat ..	Pollock	155′	29½′	13¾′	—	500	—
Schooner	Marelle	160′	27′	—	—	—	—
Cargo vessel ..	Owens Thurston ..	205′	32′	19½′	15½′ (loaded)	1,150	—
Ship	United States Shipping Board	282′	46′	28¼′	23½′ (loaded)	3,500	—
Transport	Heidenreich	—	—	—	—	up to 5,000	—
Steamer *Faith* ..	Union Ironworks ..	336′	45′	31′	24′ (loaded)	5,000	—
Pontoon (6 of them covered with a 3¼″ deck slab	Yacht Club, Zurich ..	37′ each pontoon	13′	—	—	—	2½″
Pontoon (to carry a "Châlet")	Rome Rowing Club ..	67′	21′	—	—	—	—
Pontoon	Yorkshire Hennebique Concrete Construction Co.	100′	28′	8½′	6½′ (loaded)	130	3″
Pontoon	Circular Quay, Sydney, N.S.W.	110′	53¼′ to 67½′	7¾′	—	150	bottom 5″ deck 8″
Pontoon	Panama	120′	28′	8′	—	—	2½″
Floating dock ..	Concrete Shipbuilding Co., Hamburg	240′	113′ externally, 83′ internally	—	—	5,760	—
Caisson	Norresundby	32½′	8½′	25′	—	—	3·5″-5·1″
Caisson	Alexandria	40′	37′	45′	—	—	6″
Caisson	Forsgrund, Norway ..	53′	16′	7′	—	—	
Caisson	Copenhagen	16′	16′	32′	—	—	10½-6″

From this it may be considered that a thickness of 4 in. is ample for all vessels up to 1,000 tons deadweight capacity, and that smaller vessels may be made with correspondingly thinner shells as follows :

Capacity	Thickness.
50 tons and under	1–1½ in.
100 tons	2 in.
200 tons	2½ in.
300 tons	3 in.
500 tons	3½ in.
1,000 tons	4 in.

The Danish Government have stipulated that the thickness of the concrete must not be less than 2·8 in.

The greater thicknesses used in some sand- and stone-carrying barges appear to have been devised in accordance with guesswork rather than as a result of calculation. These barges were built before any actual experimental data was available. Their excellent condition at the present day shows that an excessive amount of concrete does no harm, except in so far as it adds to the cost of constructing the vessel and of moving it through the water. The latter cost appears to be unimportant.

(*e*) *The Relation between Carrying Capacity and Displacement.*—The displacement of a ship is the weight of the water she displaces, and is therefore the sum of the weight of the ship itself and its cargo or " deadweight " capacity expressed in tons.

The efficiency of a ship as a cargo carrier depends upon the relationship between the deadweight capacity and the displacement. Expressed as a percentage, in the average cargo ship built of steel the deadweight capacity is from 70 to 75 per cent. of the displacement, taking into account as weight of ship all spars, fittings, deck houses, anchors and chains, auxiliary engines and tanks, but not boilers, engines, or coal. In a wooden ship the deadweight capacity is from 60 to 65 per cent. of the displacement. In the concrete vessel designed by the American Joint Committee (p. 77) the ratio of deadweight capacity to displacement is 60 per cent. on an 18-ft. draught. This is exceptionally good. Owing to the difference in the displacement of the materials used in shipbuilding, it will be difficult to design a concrete ship which will give a relationship between d.w. capacity and displacement approaching that in a steel vessel

Putting the matter generally, the thickness of the shell in a concrete ship would be, say, 3 in., whereas in a steel vessel it would be about ⅓ in.—that is, the former is nine times the thickness of the latter. The weight of steel is 490 lb. per cu. ft., and of reinforced concrete about 160 lb. per cu. ft., so that the weight per unit volume of the latter is one-third of the former, and in consequence the weight of the shell is three times as great in the reinforced concrete ship as in the steel vessel.

There are, of course, other weights in a ship apart from the structural parts, and these would weigh practically the same in either vessel, with the exception that the paint and pigment in a steel vessel are not required in a concrete ship. The weight of these added to the respective weight of the structural parts naturally alters the ratio of the weights. It may be taken that a barge carrying 1,000 tons deadweight if built of reinforced concrete will weigh at least twice as much as if built of steel. In other words, if a 1,000-ton concrete barge had been built of steel it would probably have carried 20 per cent. more deadweight. This is clearly shown in the following figures collected by M. Denny, and relating to a 6,000-ton deadweight capacity concrete steamer and a steel steamer of the same displacement.

TABLE III.

	Steel.	Reinforced Concrete.	
Length	375 ft.	375 ft.	
Displacement	9,900 tons	9,900 tons	
Steel	1,920 tons	680	3,150 tons
Concrete	—	2,470	
Wood and outfit	400 tons	350 tons	
Machinery	570 tons	570 tons	
Lightweight	2,890 tons	4,070 tons	
Deadweight	7,010 tons	5,850 tons	

From the above it will be noted that 1,180 tons of deadweight is lost, or 17 per cent. of that carried in the steel ship ; the bare hull of the concrete ship is 65 per cent.

heavier than that of the steel ship, and the lightweight of the concrete ship is 40 per cent. greater than that of the steel ship.

At the same time, the amount of steel used in the concrete vessel is only about one-third of that in the other, and this steel is in a cheaper form—*i.e.*, rods instead of rolled and riveted plates. An equally interesting comparison prepared by T. G. Guéritte is shown in the following table, which shows clearly that the disadvantages (as regards weight) attaching to reinforced concrete diminish with the size of the vessel.

TABLE I ONE DECK SINGLE SCREW CARGO STEAMERS.

DEADWEIGHT ALL TOLD IN TONS.	1000		2000		4000		6000	
	STEEL	FERRO-CONCRETE	STEEL	FERRO-CONCRETE	STEEL	FERRO-CONCRETE	STEEL	FERRO-CONCRETE
LENGTH BETWEEN PERPS.	180'-0"	210'-0"	220'-0"	245'-0"	285'-0"	305'-0"	340'-0"	355'-0"
BREADTH MOULDED	29'-0"	33'-6"	35'-0"	38'-9"	41'-6"	44'-3"	45'-9"	48'-0"
DEPTH MOULDED TO UPPER DECK.	16'-6"	16'-9"	20'-0"	20'-3"	25'-0"	25'-3"	28'-3"	28'-6"
MEAN DRAFT	14'-9"	14'-9"	17'-9"	17'-9"	21'-3"	21'-3"	23'-3"	23'-3"
DISPLACEMENT IN TONS.	1600	2225	2910	3660	5550	6465	8240	9210

TABLE II FACTORS FOR CONVERSION OF DEADWEIGHT CARRYING CAPACITY INTO TOTAL DISPLACEMENT.

DEADWEIGHT ALL TOLD IN TONS.	1000	2000	4000	6000
STEEL VESSELS.	1·600	1·455	1·387	1·373
FERRO-CONCRETE VESSELS.	2·225	1·830	1·616	1·535

TABLE III EXCESS DISPLACEMENT OF FERRO-CONCRETE VESSELS OVER STEEL VESSELS OF SAME DEADWEIGHT CARRYING CAPACITY.

DEADWEIGHT ALL TOLD IN TONS	1000	2000	4000	6000
EXCESS %	39%	25·8%	16·5%	11·8%

Where the carrying capacity of a vessel is measured by the bulk of the cargo this decrease in deadweight, though not without its drawbacks, is not vital, but where a heavy-weighing cargo is carried, the advantages are heavily in favour of the steel structure, unless the low cost of construction is correspondingly favourable to the concrete vessel. Curiously enough, the added weight of concrete barges, as compared with steel ones of the same load-bearing capacity, does not appear to increase the power required for towing them to any serious extent.

The difference in the conditions appertaining to river- and sea-going vessels enables considerable variations to be made in the designs of each of these classes of vessels, and it is therefore convenient to arrange them in the following groups : (i) small boats, chiefly used for pleasure ; (ii) barges or lighters ; (iii) self-propelling vessels, including towing boats and steamers. It is also convenient to pay some attention to (iv) pontoons ; (v) floating caissons ; and (vi) buoys.

SMALL BOATS.

Small boats, whether propelled by oars or a small motor, present few problems to the designer. Indeed, A. A. Boon, of Amsterdam, constructed one of the earliest

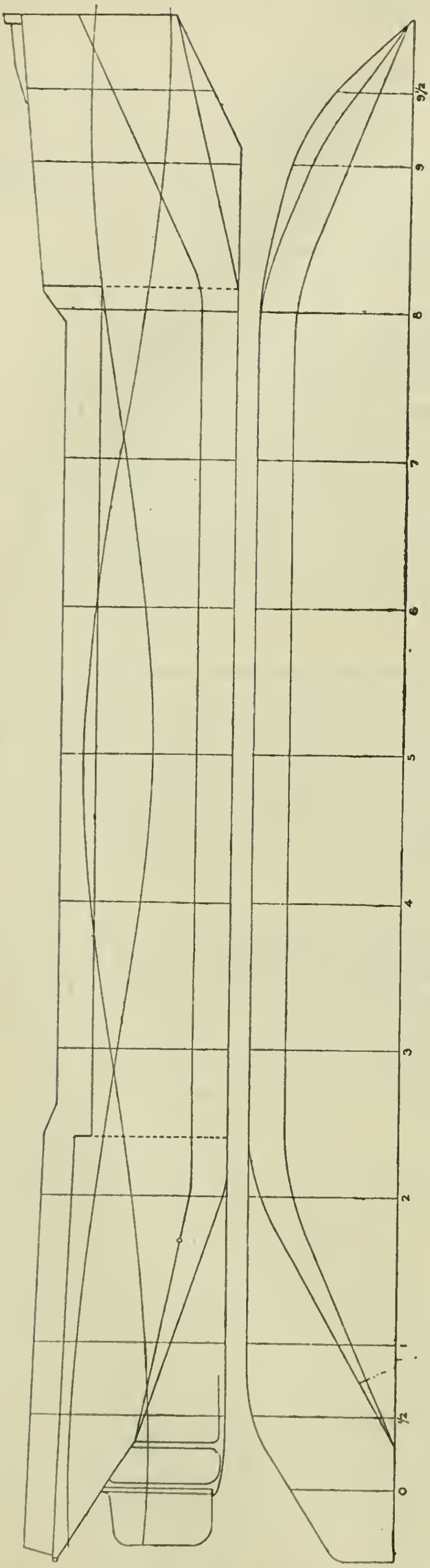


Fig. 72. Straight form design by W. Pollock.

concrete boats by using an old and damaged rowing boat as a core, covering it with a network of steel rods of small diameter tied at right angles to each other, and then laying on concrete until the metal was entirely covered. After the concrete had hardened he attempted to cut away the wooden boat, but found this so difficult on account of the adhesion of the concrete boat, he let it remain. This concreted boat (*Figs.* 5 *and* 6, *see November Supplement*) has been in use for nine years without needing any repairs.

In another successful small boat, built in 1910 by R. Last & Son, in Holland, the shell is only ½ in. thick, and was built of wire mesh attached to steel ribs, the whole being plastered over with a fine concrete.

A concrete rowing boat built in Scotland is described on p. 32 (*December*).

A small boat, which at one time aroused a considerable amount of interest (*Fig*. 20, *November*), was built by W. M. Dowsey (see p. 14). In this boat the keel consists of a T-bar, the ends of which have been turned up to form prow-posts. The framework of the boat was then formed by riveting flat steel strips of No. 12 gauge on to the keel at right angles to its length and at 12-in. centres so as to form the ribs. Several similar strips of steel were then riveted longitudinally, from stern to stern, on the ribs, at 12-in. centres. This framework was then covered with wire netting of ¼ in. mesh, and this was embedded in concrete with a trowel, so as to form a finished shell ¾ in. in thickness.

A small motor-boat built by Muribloc, Ltd., is shown in *Fig*. 39, p. 32 (*December*). She was completed in 60 hours' working time from the laying of the keel plate, and launched in 10 days after completion, having to shoot off the ways and drop 5 ft., but in doing so sustained no damage. The keel plate was laid and stem and stern posts erected as in ordinary boat building; the frames were then set up and faired, and the whole sheeted with expanded metal and faired to lines ; the concrete was then applied, under pressure to both sides simultaneously, the result being a thin hard skin of great strength.

In a small boat built in Germany, the keel was made of a 1-in. iron bar, to the ends of which cross-rods were attached. The sides of the boat were then formed of stout netting of 1½-in. mesh, and this was covered on both sides with wire gauze. The skeleton was then plastered with concrete, forming a shell ½ in. thick.

In D. Wilson's patent (Eng. Pat. 16350—1887) for a boat 10 ft. long, netting of ¼-in. mesh, formed of No. 16 Birmingham gauge steel wire, is used for the frame, and the coatings of cement or concrete may be of such thickness as to make the entire thickness from surface to surface ½ in.

What appears to be an excellent method for constructing small concrete boats is that patented by I. Chiera & Co., Gabellini (Eng. Pat. 3,827—1897), and shown in *Figs.* 73, 74, and 75. A skeleton of round bars *A* (*Figs.* 73 and 75) is first constructed and is covered with wire netting or expanded metal *B*, which is fastened to the bars by wires, the whole being then enveloped in concrete *C*, the outer surface of the concrete being carefully polished. This arrangement, or some simple modification of it, appears to be in general use for small concrete boats.

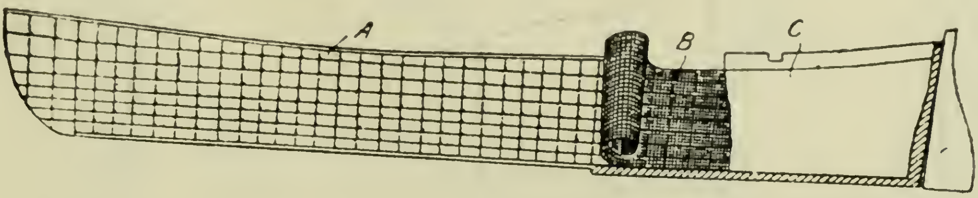


Fig. 73. A Longitudinal view of a boat with the wire netting or reinforcement rolled back.

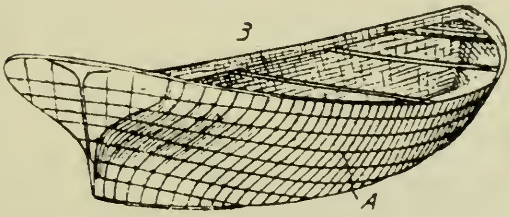


Fig. 74. A Perspective view of the wire netting.

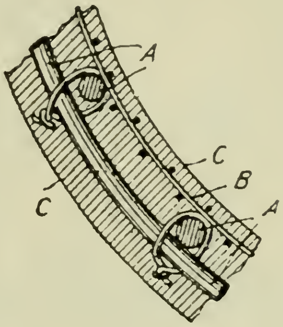


Fig. 75. A cross section of part of the boat's side showing the framing, the netting, and the ties uniting them.

An arrangement patented by N. Fougner (Eng. Pat. 29,939—1912) for small craft consists of a vessel with a flat bottom, outwardly sloping sides, watertight bulkheads, a solid deck over the ends of the vessel from the bulkheads, central beams to these decks running from centre piers in the bulkheads to the ends of the vessel, or with a deck having a central well or hatchway provided with a coaming and removable hatches, leaving a narrow deck at the sides, the side decks being constructed to act as beams turned sideways.

Fig. 76 shows a half-side elevation and half longitudinal section through the vessel, the section being taken on the line of the half horizontal section with the deck removed, and half-deck plan shown in *Figs.* 77 and 78 shows a cross section of the vessel, and the right half of the illustration presents a view of the interior construction of one end, the bulkhead being removed ; the section is taken on the line 3—3 of *Fig.* 77.

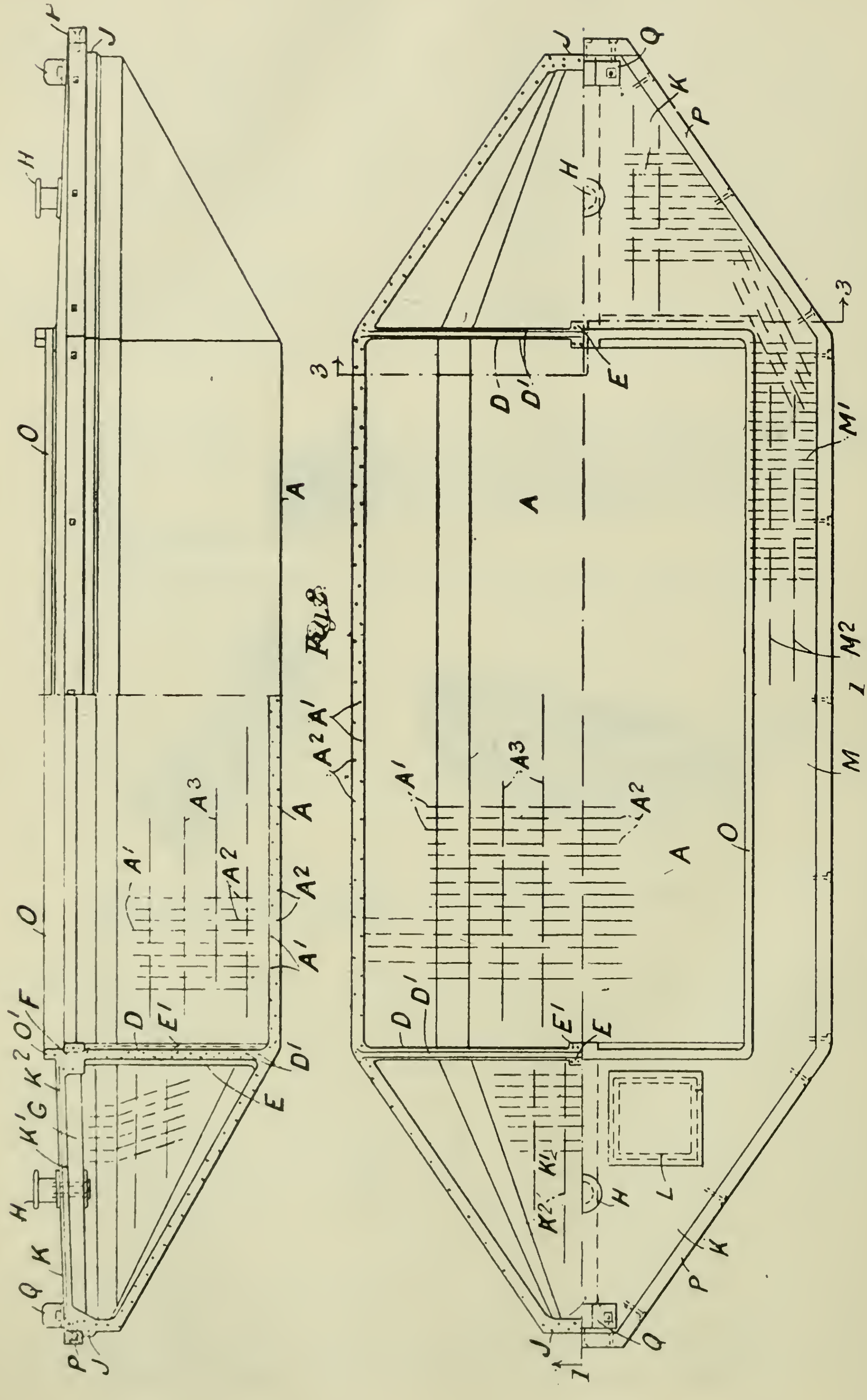


Fig. 76. M. Fougner's Patent (A Half-side Elevation and Half Longitudinal Section).

Fig. 77. A Half Deck Plan.

The bottom *A* of the vessel consists of a flat slab reinforced near its upper and lower surfaces by transverse rods A^1 and A^2 and longitudinal ones A^3 in the centre; the sides are similarly reinforced with rods A^1, A^2.

The inside rods absorb tensional stresses caused by water pressure, while those near the outside face take the stresses when a cargo or other mass is heavily thrown against the inside.

At the junction between the sides and bottom the slab is considerably increased in thickness at *B*, and is provided with additional short continuity-rods placed near the outside face parallel to the other rods, in order to take care of the negative bending moment caused at this point by the water pressure.

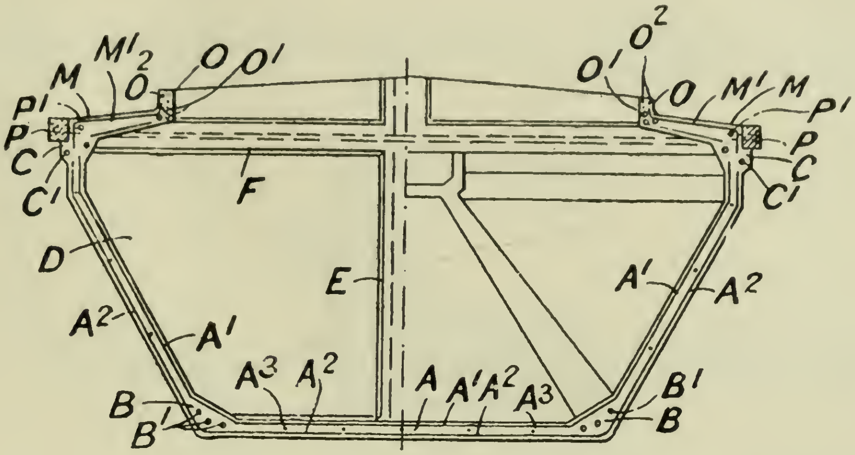


Fig. 78. A Cross Section, also showing interior section of one end.

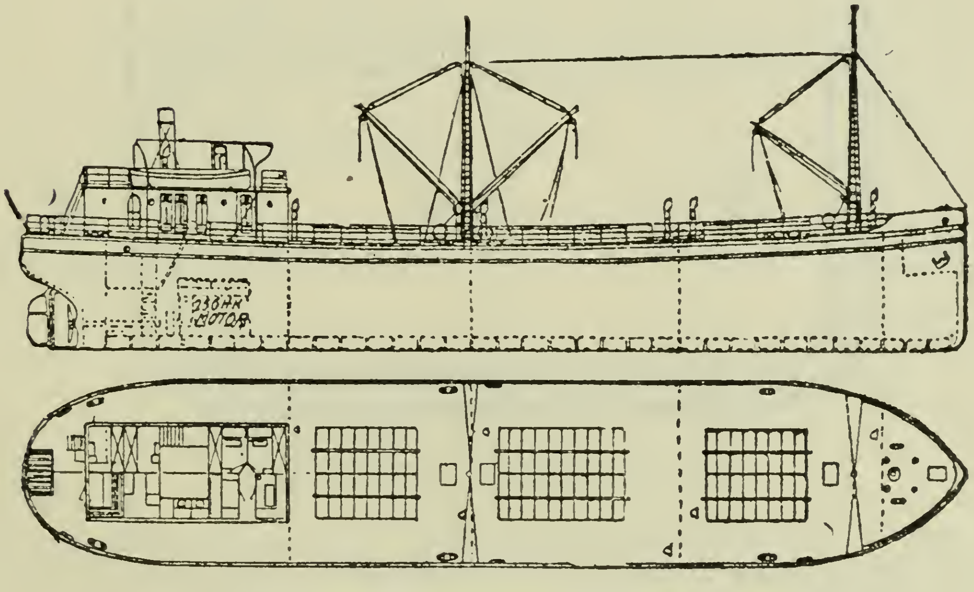


Fig. 79. 600-ton Concrete Vessel Built for the Norwegian Government.

At the same point, *B*, a number of rods, B^1, are placed longitudinally to take up the tension caused at these points by the beam action of the sides when the vessel is supported momentarily on heavy waves fore and aft. The large longitudinal rods C^1, at the thickened top point *C* in *Fig.* 78, perform the same function in providing for the negative bending moment caused by the waves.

All the rods in the sides and bottom may be continuous or in separate lengths as may be required, but the main reinforcement should always run transversely near both surfaces.

The reinforcing rods D^1 in the bulkheads *D*, *D*, run transversely, and a few temperature rods are placed vertically in the centre of the slab, the main reinforcing rods being placed similarly to those in the sides and framing into the pier or vertical beam *E*.

The beam *F* transmits the reaction from the pier, *E*, to the sides of the vessel in case of water pressure coming on the bulkhead and also takes up the reaction from a beam, *G*, which supports the deck slab, *K*, and acts as a stiffener in case of collision. It is reinforced by rods placed near the top and bottom and bent down into the beam *F* and a front slab, *J*, which securely ties the structure together.

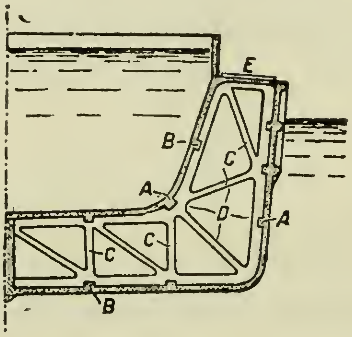


Fig. 80. C. Gabellini's method of construction.

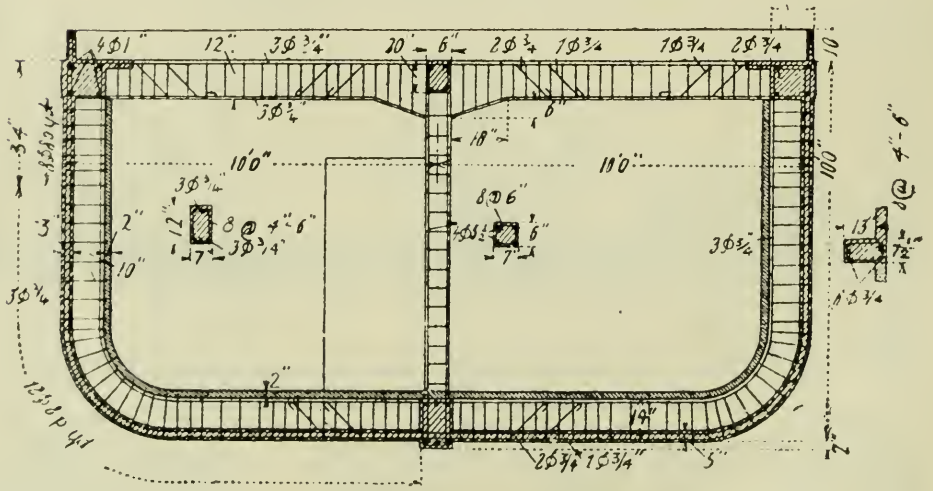


Fig. 81 Concrete Lighter for use on the Adria.

The deck *K* covers the fore and after portions of the vessel between the bulkheads *D* and the extreme ends *J*, and is provided with small covered hatchways *L*. It is reinforced by rods K^1 and a few longitudinal shrinkage rods K^2.

The central portion of the deck *M* between the bulkheads *D* at the sides of the large open well or hatchway is cantilevered out from the sides, as shown in *Fig.* 78 The reinforcing rods M^1, placed transversely near its top surface, are bent down to near the sides of the vessel and absorb all tensile stresses from loads placed on the deck. The deck *M* also acts as a horizontal beam turned sideways, and the sides are prevented from collapsing by longitudinal rods O^1 and P^1 and by the usual temperature rods M^2; a few additional rods are provided at the corners of the hatchway.

The coaming *O* is reinforced longitudinally by a few light rods O^2 and by the ends of the deck reinforcement M^1, which are bent into it.

BARGES AND LIGHTERS.

Barges and lighters are vessels used for the transport of cargo and towed by means of a horse or a self-propelling tug-boat. The simplest form of barge consists of a perfectly plain hull, but other patterns are divided into various compartments. Barges which carry their own means of propulsion are described later.

A concrete barge designed as closely as possible on the lines of a steel or wooden vessel is shown in *Fig.* 79. Owing to its curvelinear form this vessel was costly and troublesome to build, it being difficult to keep the reinforcement in position during the application and hardening of the concrete (see p. 73). It has, however, proved quite satisfactory in use. The reinforcement consists of bars of small cross-section placed closer together than those in the boats previously mentioned and tied by oblique and crossed hoops.

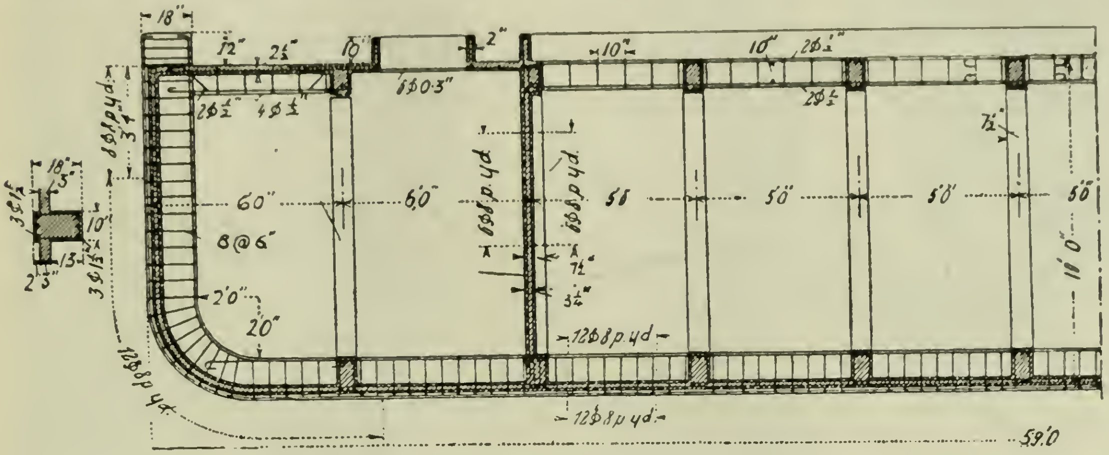


Fig. 82. Concrete Lighter for use on the Adria.

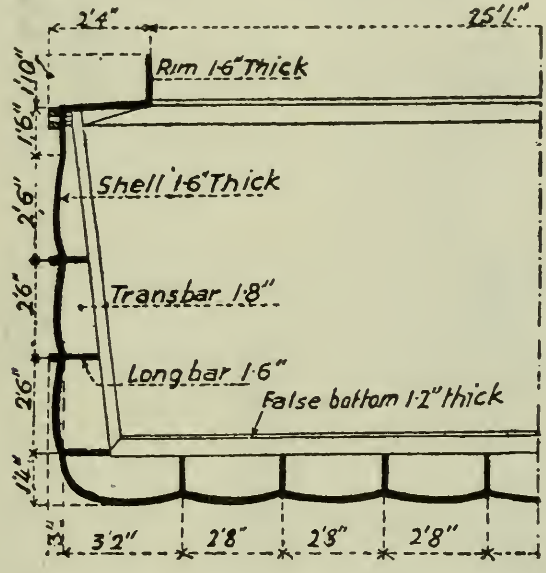


Fig. 83. Half Section of Vessel shown in Fig. 84.

Barges of the "straight line" type are simpler and cheaper to build, and are equally serviceable. The arrangement of the reinforcement is similar in all those concerning which constructional details are available, but two main groups may be distinguished. The first group contains barges built with a double shell, the two parts being connected by a series of short walls or spacers which are made of reinforced

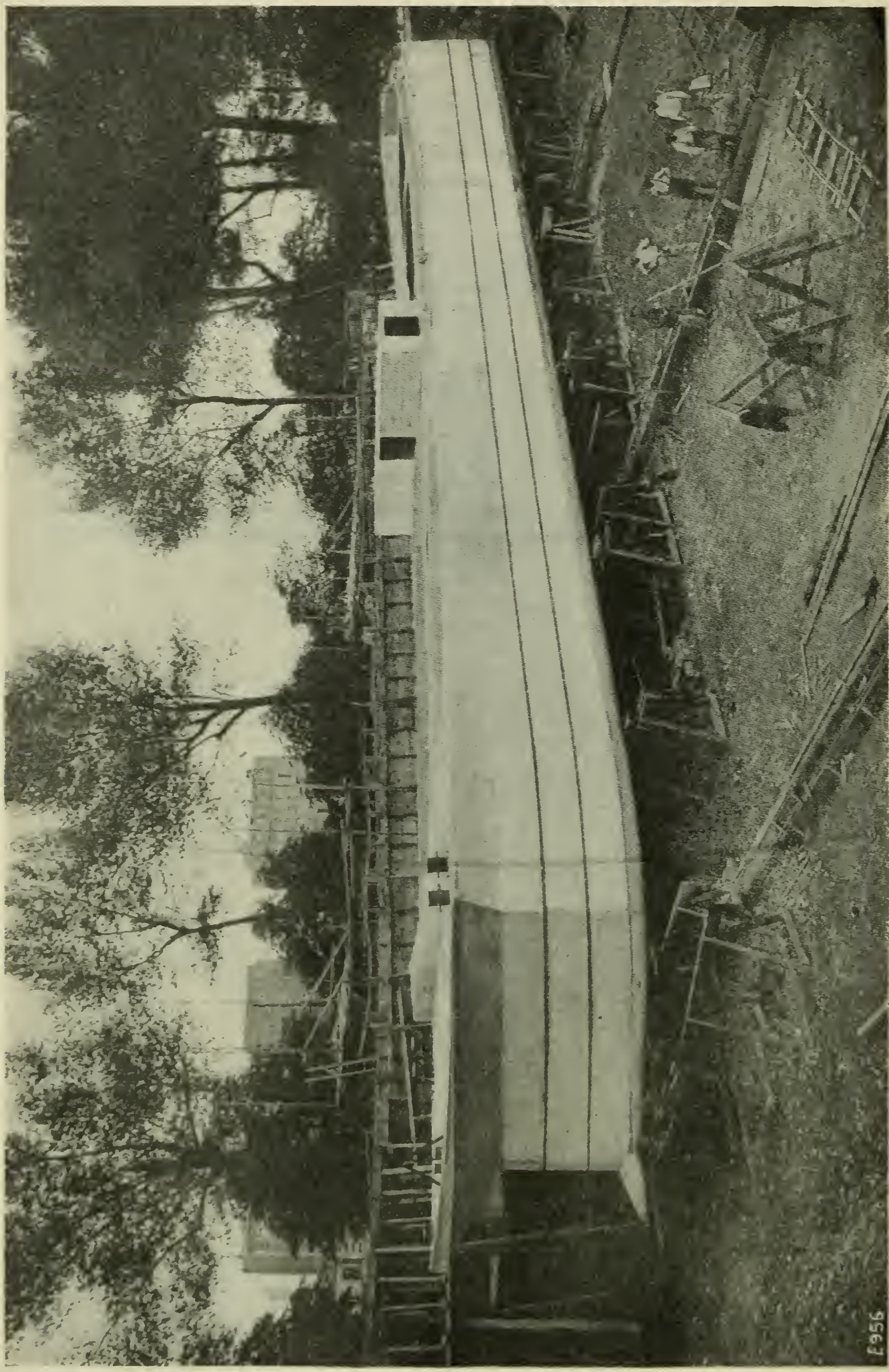


Fig. 84. A Completed Concrete Vessel (Lorton System).

concrete. The space between the inner and outer shells is thus divided into a series of compartments, which may be either independent or connected as desired by the designer. One object in making the compartments independent of each other is to form a series of watertight compartments which will retain their buoyancy in case of an accident to the vessel. Unless filled with oil or other liquid cargo a double shell adds greatly to the weight of the vessel without any valuable advantage. The use of large water-tight compartments affords all the advantages of the smaller ones without their defects.

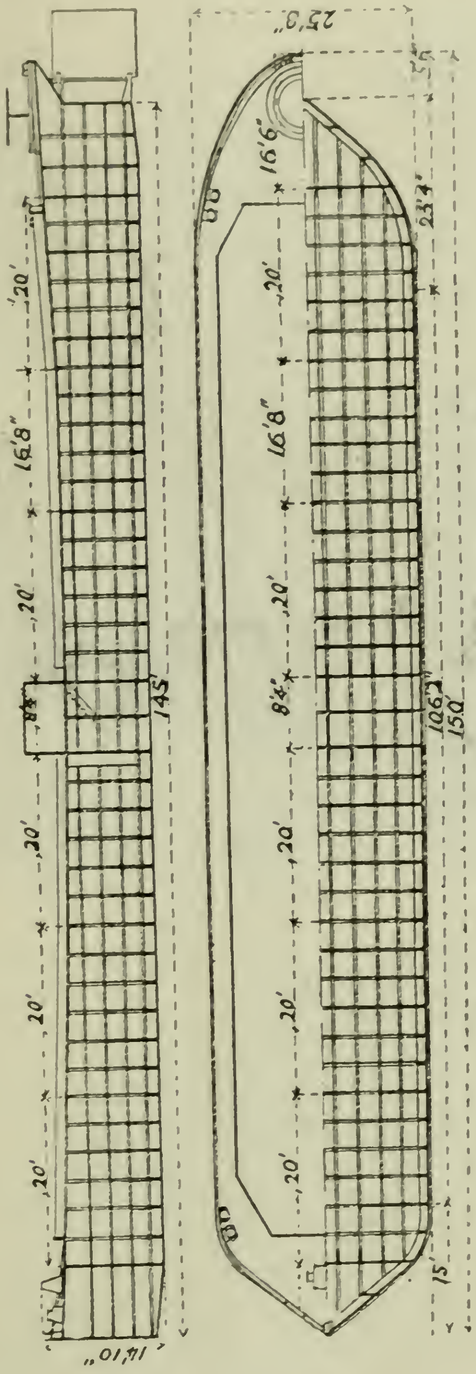


Fig. 85. Sections and plan of Concrete Vessel (Lorton System).

The pioneer construction in concrete vessels with double hulls appears to have been that of C. Gabellini, of Rome, patented in this country by J. O. O'Brien (Eng. Pat. 23,092—1908). The principle underlying this method of construction is shown in *Fig.* 80 to consist of a double hull *A*, *A*, the two portions of which are united by tie-walls *C*, *C*, which are sufficiently far apart for a man to pass between them and make any necessary repairs. Longitudinal ribs *B* strengthen the two hulls. Access to the cells *D* is gained through a series of covers *E*.

A concrete lighter (*Figs.* 81 *and* 82) for use on the Adria was built by the Oesterr. Eisenbeton-Schiffbau-Unternehmen, and is 58 ft. by 20 ft. by 10 ft., with a capacity of 150 tons, the total weight when fully loaded being 230 tons. The thickness of the hull is 3¼ in. The reinforcement is 3 per cent. of the weight of the vessel. This lighter was built with double shuttering and required 60 days for its construction.

A typical example of the double shell system is that used by M. Lorton in France and shown in *Figs.* 83, 85 *and* 86. *Fig.* 83 shows, on a larger scale than *Fig.* 85, the curved sides of the vessel, the inventor claiming that, by constructing these in a series of curves, it is possible to obtain a greater strength than with straight sides, and consequently the thickness of the outer shell of a barge of 700 tons deadweight capacity can be reduced to 1½ in. and the weight of steel reinforcement to 12 tons. In the barge illustrated in *Fig.* 84 and launched near the confluence of the Marne and Seine on November 5th, 1917, the walls are strengthened by a webbing 1½ in. thick, which forms a series of compartments, each 2 ft. 8 in. by 2 ft. 6 in. The reinforcement is arranged to form these compartments as shown in *Fig.* 84. The frames are 22 in. high and are spaced 40 in. apart on the base but their vertical parts are slightly narrower. The whole system is strengthened by four closed bulkheads, one fore, one aft and two midships, and leaving two large holds, each 56 ft. 8 in. by 22 ft. 8 in., for the cargo. The gunwales which limit the hatchways of these holds are T-beams spaced 20 ft. apart.

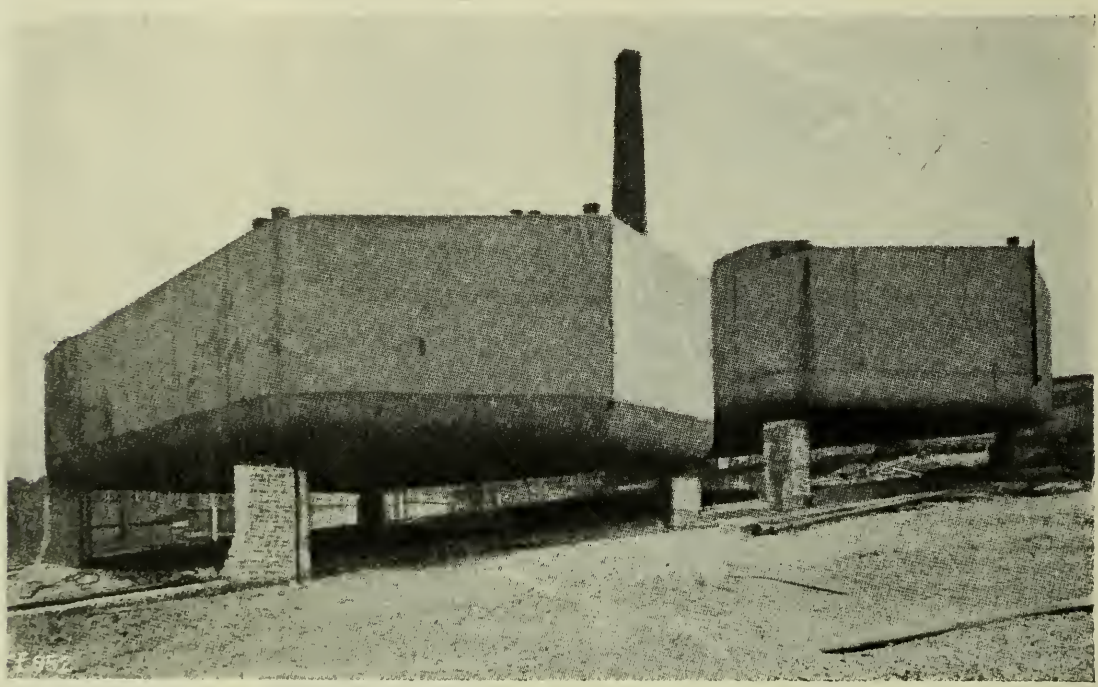
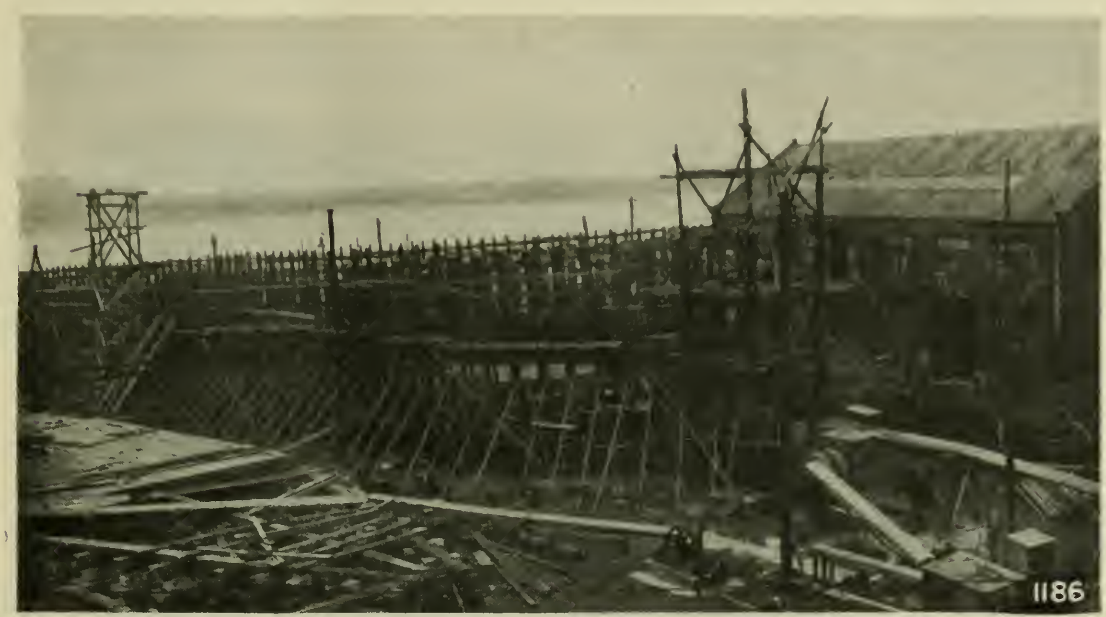


Fig. 86. A Concrete Vessel (Lorton System).

(*To be continued.*)

THE CARGO STEAMER s.s. "ARMISTICE."

The launch of the s.s. *Armistice* from the Ferro-Concrete Ship Construction Company's yard on January 7th, 1919, marks a notable event in the shipbuilding activities of the Port of Barrow-in-Furness, as this is the first self-propelled, sea-going cargo steamer of over 1,000 tons deadweight built in this country.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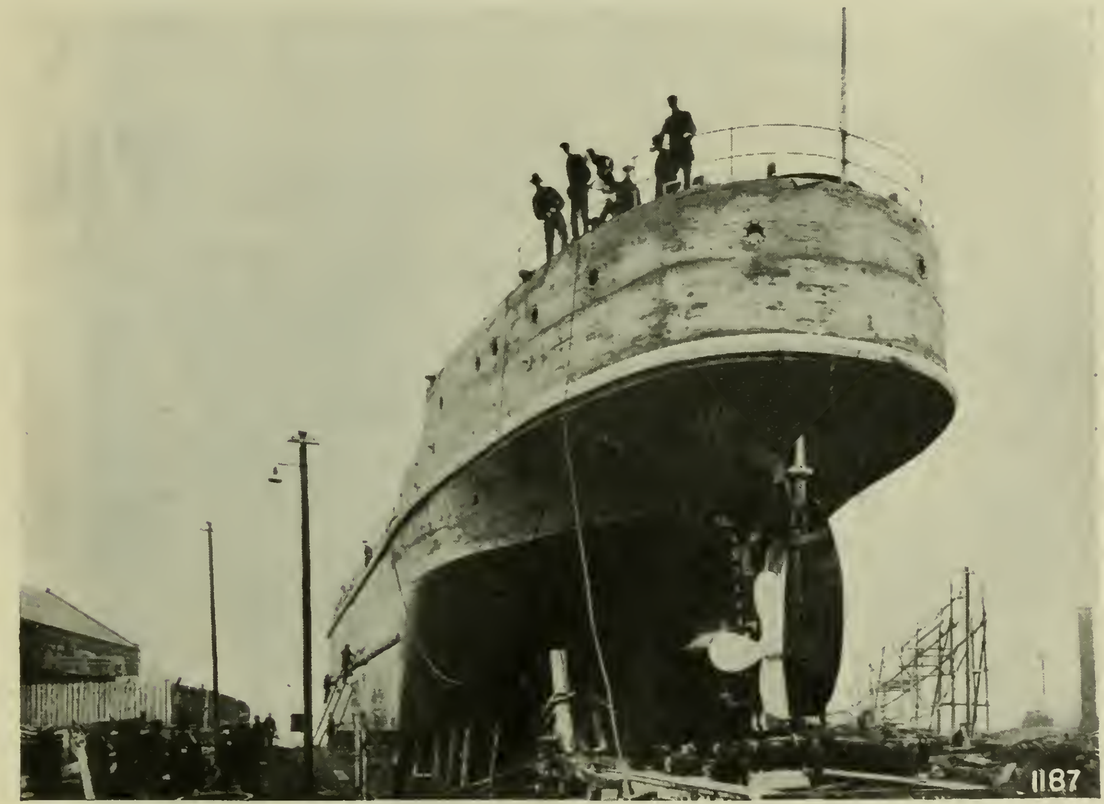
Shuttering for Frames and part of Shell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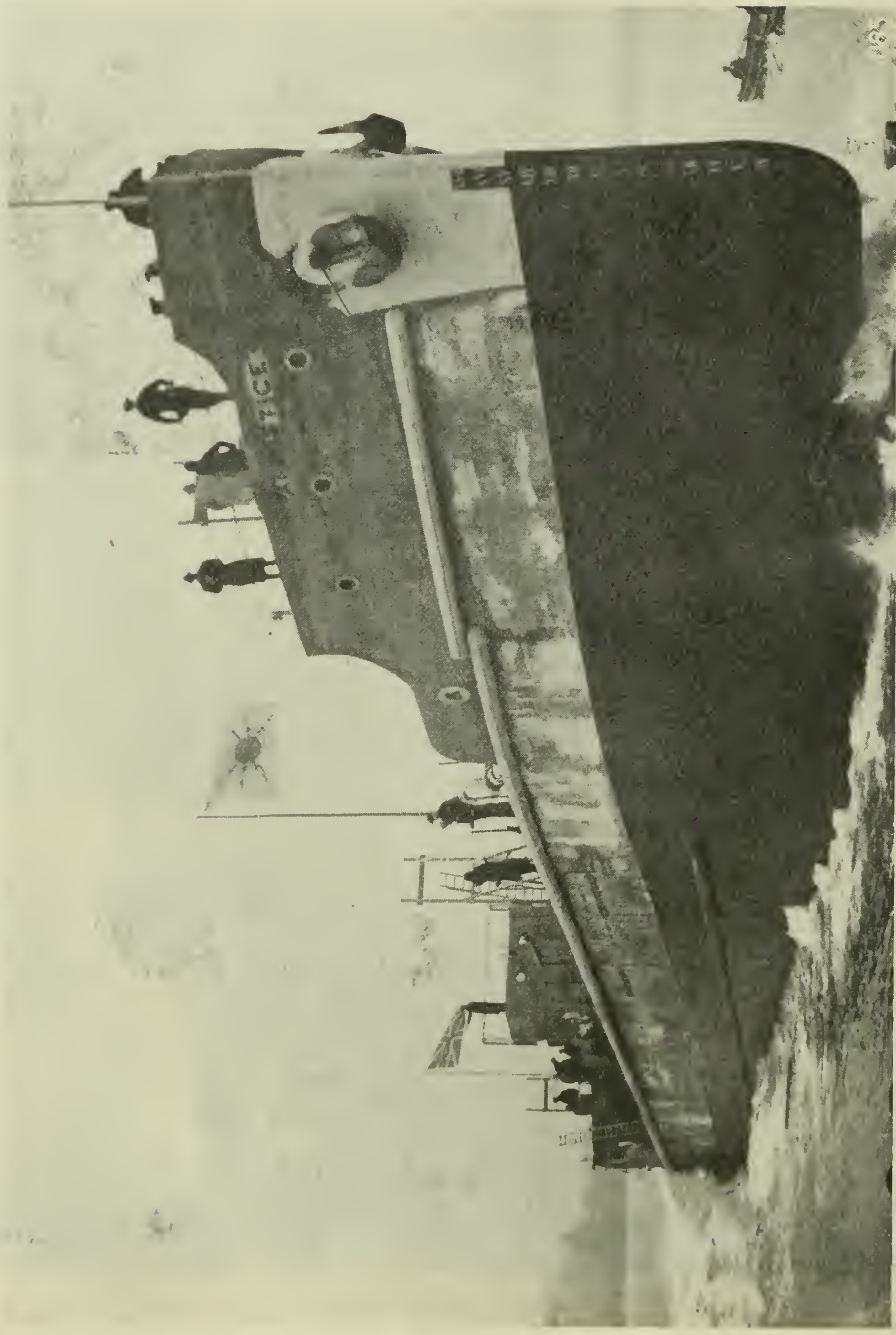
Stern View of Vessel
The s.s. "Armistice."

The vessel has the following general dimensions :—

Length between perpendiculars		205 ft.
Breadth		32 ft.
Depth		19 ft. 6 in.
Draught		15 ft. 9 in.
Deadweight		1,150 tons.
I.H.P.	(about)	400.
Speed	(about)	8 knots.



The Launching of the "Armistice."

The s.s. *Armistice* has been built to the designs of Mr. T. G. Owens Thurston, managing director of the company, and is the forerunner of a series of vessels of similar type to be constructed by this company, which was newly formed in the autumn of 1917 for the purpose of constructing ships of reinforced concrete, and thereby adding to the output of mercantile tonnage of a type of vessel using less than half the amount of steel necessary for the construction of steel ships of similar carrying capacity.

The design was very thoroughly considered in a paper read by Mr. Owens Thurston, M.I.N.A., before the Institution of Naval Architects, and the investigations show conclusively that the reinforced concrete hull is as strong, and certainly more substantial, than the standard required by Lloyd's for a similar size of sea-going steel vessel.

Shortly after the company had commenced to build, their yard was extended to comprise twelve slipways, suitable for the building of reinforced concrete barges and tugs, for which orders were given by the Auxiliary Shipbuilding Department of the Admiralty; and the company is at present actively engaged in the building of Admiralty vessels to the above programme, for which several have already been launched and delivered.

The design of the reinforced concrete construction of the hulls has been prepared by Messrs. Mouchel & Partners, to conform to Lloyd's Classification A1 standard, and all the vessels are built on what is known as the Hennebique System, using round steel bars and stirrups to reinforce the concrete shell and framing.

The frames generally are 3 ft. apart, 16 in. deep and 5 in. thick. A solid concrete stringer, about $24\frac{1}{2}$ in. deep, extends all fore and aft at the deck level. This stringer is reinforced by bars $1\frac{3}{8}$ in. and $1\frac{1}{2}$ in. dia., suitably reduced at ends. The chine stringer at the bilge runs fore and aft, of reinforced concrete, about $19\frac{1}{2}$ in. deep, by $19\frac{1}{2}$ in. wide, the reinforcement bars being $1\frac{1}{2}$ in. amidships, reduced suitably at the ends. The thickness of the shell is about 4 in. and the decks 3 in.

In the construction of the *Armistice* the steel used amounts to 200 tons, composed of bars varying from $\frac{1}{4}$ in. to $1\frac{3}{4}$ in. diam., and the concrete is formed of granite chippings, sand and Portland cement (Earle's brand) in the proportion of 2·4 is to 1·2 is to 1, which gives a high compressive strength, allowing the working stress to reach 800 lb. per sq. in., and in the steel 16,000 lb. per sq. in. tensile stress. Fresh water was exclusively used for mixing the concrete. The method adopted in construction was to build a box around the reinforcement bars in which the concrete was poured and rammed round same. In order to reduce the timber used a system of steel sheets was adopted, suitably stiffened to act as shuttering.

The concrete hulls have proved perfectly watertight, and no leakage has taken place in the barges, which have carried their full cargo in a heavy sea.

We learn from the *Times* that the *Armistice* successfully completed her maiden voyage to Londonderry during February. Heavy weather was encountered, but the vessel behaved in an entirely satisfactory manner and there was a complete absence of vibration.

THE s.s. "ELMARINE."

On January 4th a reinforced concrete ship, the *Elmarine*, was launched from the shipyard of Concrete Seacraft, Ltd. (E. Williams, M.I.N.A., managing director).

Hitherto all the boats launched in this country or abroad have either been of the usual monolithic type or, as in the case of the Norwegian craft, of plastered construction.

The boat under description has been built in an entirely novel way. Instead of being built in one mould into which is poured the concrete, which forms the frame and plates of the finished ship, she was constructed of a large number of pre-matured units of concrete, and then erected on the slip in much the same way as the frame and plates of an ordinary steel ship.

The units are connected together by means of diagonal bars which bind the whole structure together between the main longitudinal members, which are cast *in situ*.

It is claimed for this boat, the *Elmarine*, that she is the lightest concrete boat of her size which has received Lloyd's classification; the thickness of the sides is only

$1\frac{3}{4}$ in instead of $3\frac{1}{2}$ in., which is the requirement of Lloyd's for boats built in the monolithic manner, and tests carried out on these thin slabs show that with a 90 ft. head of water remaining on four days the percolation of the concrete is invariably less than $\frac{1}{8}$ in. Her capacity is 250 tons D.W., 85 ft. in length, 21 ft. 4 in. beam and 8 ft. 6 in. draft. The boat was designed by Messrs. Ritchie & Black, civil engineers, Royal Liver Building, Liverpool, in accordance with the invention of Mr. Harry C. Ritchie, A.M.Inst.C.E., etc.

The frame spacing of this boat is the same as for steel boats of the same class in accordance with Lloyd's Rules. An advantage claimed for this method of spacing in concrete boats is that a comparison can be made with the equivalent strengths of the steel frames of a steel boat.

One of the objects of the Ritchie System of Concrete Shipbuilding is to produce as close a parallel as possible to steel shipbuilding, both in the actual method of building and in structural design.

Another advantage claimed in building concrete boats with pre-cast members is that any defect in workmanship can be easily seen before the unit is incorporated into the structure, and easy remedy is therefore provided. This is an important consideration in the effort to better the classification of concrete ships in the register of the Classification Societies, and this has been recognised in many quarters. A recent report by the chief engineer of the Italian Naval Register (Ing. Domenico Barricelli) contained the following :

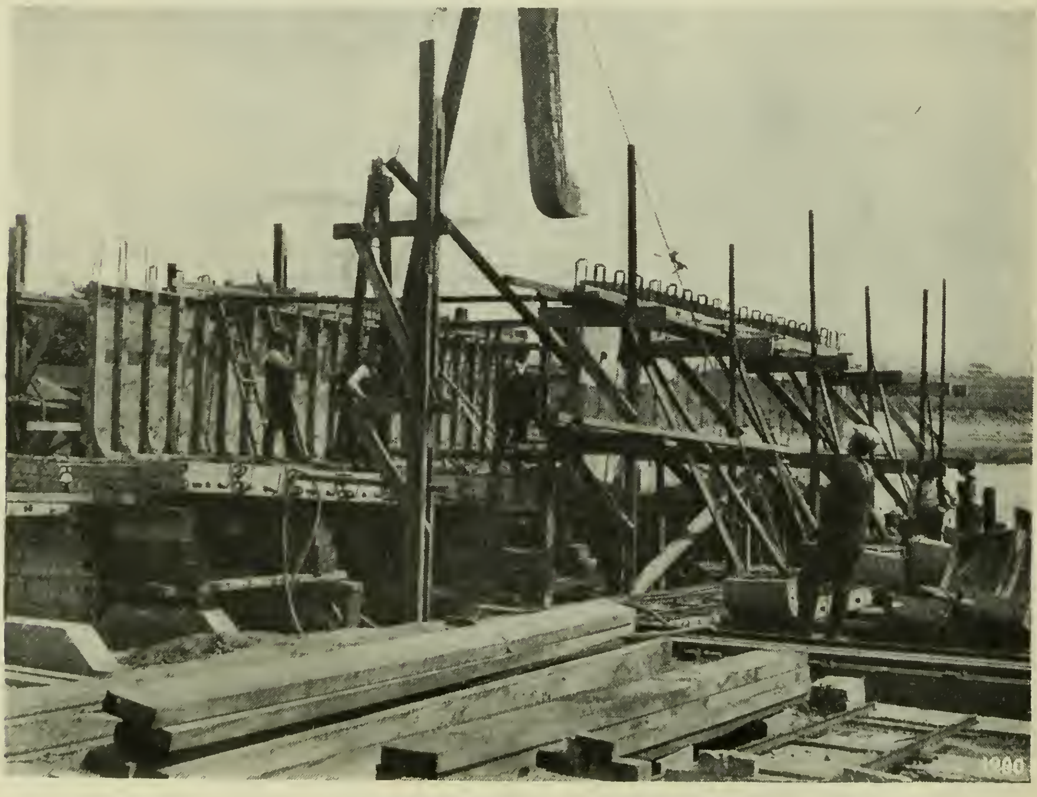


Fig. 1. "The Elmarine" in Course of Construction.

> The survey and the efficiency of the inspection of a Reinforced Concrete Ship during its construction becomes a rather complicated matter in the case of a monolithic structure, but it is reduced to a minimum in the case of construction by "elements" or "units."
>
> In such a construction the selection and the survey of each member can be done separately. Before assembling them on the slipways each unit can be tested as far as good quality of material and its resistance to a specified stress is concerned.
>
> On this subject I should like to call particular attention to a system of Ship Construction in Units already in use in England, in which the units comprising floor plates and shell, side frames and shell, and the deck beams are pre-cast in moulds and erected in their place in the hull, after a period of maturing.
>
> These pre-cast members are of reasonable dimensions easy to handle and possible to inspect before incorporation in the ship.

In our opinion, this system, when experience has proved its adaptability to ships of large dimensions, constitutes an enormous advantage to a Classification Surveyor in his task of inspection.

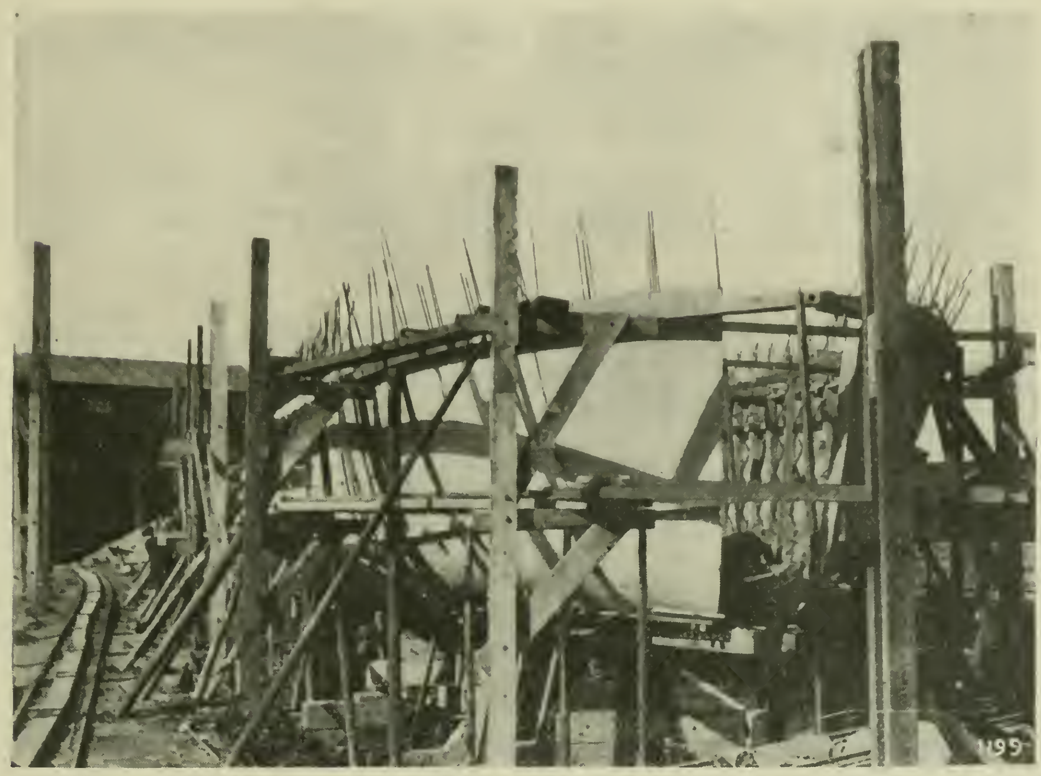
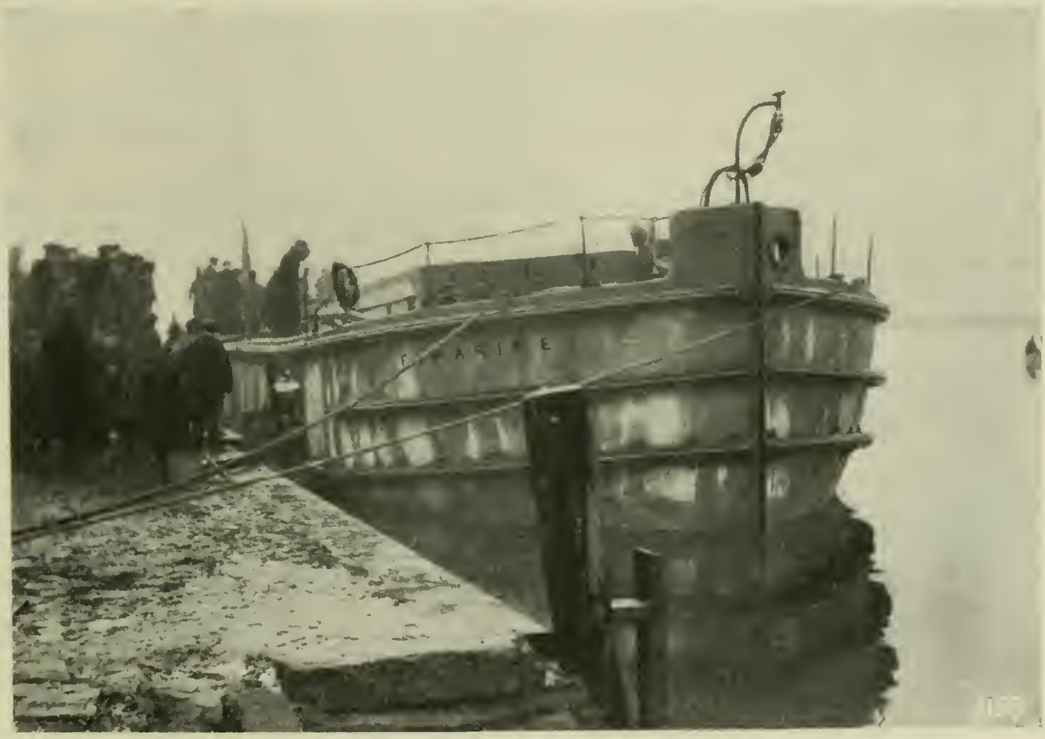


Fig. 2. Vessel nearly Completed.



The "Elmarine" after Launching.

It is further stated that the method of building in units is the only method by which it is possible to reduce the shell thickness ; the practical difficulty of casting large areas of concrete slabs between two parallel faces of timber sheeting compels resort to a slab thickness which has a very marked disadvantage in weight. These units also, cast as they are horizontally, can be trowel finished to a great smoothness, and it is claimed that a concrete hull constructed in the special manner described has in this quality an appreciable set-off against the reduced propulsion efficiency due to extra structural weight as compared with a steel hull.

The first illustration shows the *Elmarine* in course of construction, with a portion of her floor plates and side frames in position and a side frame unit being lowered into its place in the structure.

Illustration No. 2 shows the vessel in an advanced state of construction, the stern unit only requiring to be placed, and Figure 3 shows the *Elmarine* lying alongside the wharf after launching.

SOME MEMORANDA.

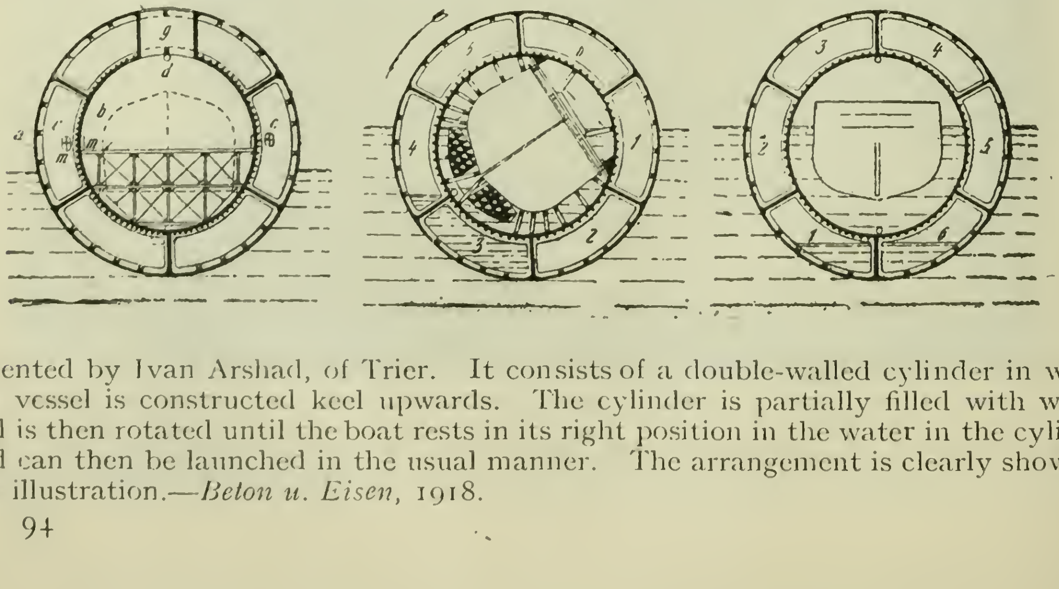
The Most Economical Size of Concrete Ships.—The results of a very careful study have convinced Mr. E. O. Williams (*Engineering*, cvii., 196) that the most economical sizes for concrete ships are deadweights of 1,500-4,000 tons, and the best size, considering initial cost of hull, indicated horse-power and saving in steel, is in the neighbourhood of 3,500 tons deadweight. No concrete ship under 4,000 tons deadweight should require more than 10 per cent. extra propelling power compared with a steel ship of the same capacity. In vessels under 1,000 tons deadweight the saving of steel is very considerable, being over 90 per cent. for 100 tons deadweight, and this alone will in many cases lead to the adoption of concrete. If, however, the object is to increase tonnage at minimum cost and irrespective of size of ship, it would be advisable to build vessels of about 3,500 tons deadweight.

Vessels above 8,000 tons deadweight are not economic in concrete because the saving of steel diminishes, and at 12,000 tons deadweight is zero. The cost of hull per ton deadweight and the displacement rapidly increase and consequently the indicated horse-power is greater, whilst the net tonnage carried is reduced.

If steel of a higher tensile stress than 7 tons per sq. in. were used and the ratio of concrete to steel remained constant, the weight of concrete could be reduced, provided it could stand the still higher demands made upon it. The weight of hull would be correspondingly reduced and the economic limit of size increased slightly.

Another possible means of reducing the displacement of concrete ships would be by the use of a concrete of lower specific gravity, and this is the most likely and immediate improvement.

A Rotary Floating Dock for Concrete Vessels.—It is well recognised that vessels of concrete can be built most satisfactorily with the keel upwards; after completion they must be inverted in the water. In Alfsen's Norwegian patent the vessel is built on a shoe or sledge on which it is launched. Water is then allowed to enter the hull, which soon rights itself. A method which is more suitable for large vessels has been patented by Ivan Arshad, of Trier. It consists of a double-walled cylinder in which the vessel is constructed keel upwards. The cylinder is partially filled with water, and is then rotated until the boat rests in its right position in the water in the cylinder and can then be launched in the usual manner. The arrangement is clearly shown in the illustration.—*Beton u. Eisen*, 1918.



Cement Clinker for Concrete Ships.—The use of cement clinker as an aggregate for concrete ship construction has been the basis of experiments by Mr. Victor C. Coxhead, President of the International Concrete Ship Association.

The experiments were carried out at the University of Washington, Seattle. It is stated that a 1 to 3 concrete mix that will weigh 105 lb. to the cu. ft., with a compressive strength in a seven-day test of 4,863 lb. per sq. in. and 9,240 lb. in 28 days, with a density test showing an absorption of less than 2½ per cent. of moisture, has been obtained by the use of cement ground to a fineness of 97 per cent. through a 200 mesh before calcining and on the finish would grow to 95 per cent. through a 200 mesh, using clink that was 60 days old, and finished cement freshly ground, together with an aggregate composed of hard burned clinker, fresh from calcining, crushed and ground to take up voids and graded from ¼ in. down to the 100 mesh size.

Mr. Coxhead also states that he is working on concrete ship construction without wooden forms of any kind, using expanded metal attached to the reinforcement and placing the concrete with a gun.—*Concrete, U.S.A.*

Reinforced Concrete Ships at Queenborough.—Among the many shipyards recently established for the construction of reinforced concrete ships is that of the Queenborough Shipbuilding Co., at Queenborough, Kent. The area of the premises is approximately four acres, and two building berths have been laid down on which 1000-ton barges are being built. These vessels measure 180 ft. in length, with a breadth of 31 ft. and a depth moulded of 19 ft., while the loaded draught is 15 ft. The berths are composed of clinker strengthened with concrete slabs, and the ends away from the water have been built up to a depth of 8 ft., to give the necessary incline. At the lower ends are solid concrete aprons, supported by piles, which also take the launching ways. A third berth is under construction for craft with deadweight capacities up to 4,000 tons, while plans have been made for a fourth for even larger vessels. The various sections of the yard consist of a carpenter's shop, with a circular saw, planer and band saw, and a bar-bending shop with forge, bending machines and tackle for making steel fittings. The concrete is prepared by two mixers and one stone crusher, all driven by electric motors, for which current is derived from the Sheppey power station. It is composed of 1 part cement to 1⅓ parts sand and 1⅔ parts of Thames ballast. The mixed concrete is transported to the ship in tip-wagons, which run on a rail track with a 2 ft. gauge, the concrete being discharged into chutes which deliver it where required. The yard is in direct communication with the South-Eastern and Chatham Railway, and a 3-ton steam crane forms part of the equipment.

The materials for the concrete are all obtainable in the vicinity of the yard, cement making being a notable industry on the Medway, while sand and ballast are plentiful. Only the steel and timber have to be brought from a distance.

Electric welding is used in the place of wire ties for much of the reinforcement employed in this yard, but the process is not carried on at Queenborough, the welded parts being supplied ready for erection by the steel makers.—*Motor Ship and Motor Boat.*

Concrete Ships for India.—The possibilities of building reinforced concrete ships in India were discussed at the fourth meeting of the Bombay Engineering Congress by Mr. G. F. Manson.

He expressed the opinion that India is a particularly suitable country for the construction of such ships, since in order to build steel hulls the plates must be imported, at any rate until the Tata Iron and Steel Works have their plate mills installed. On the other hand, steel rods of the kind needed for reinforced concrete construction are made in India, while practically all the shipyard plant required, such as crushers, mixers, screens and hoists, can be obtained in the country. Moreover, the variety of trades required in building reinforced concrete hulls is less than with steel ships, and a comparatively small amount of skilled labour (which is scarce in India) will suffice. The author considers that the climate in the East is most suitable for this work, since the frosts, which are a serious handicap in the West, have not to be contended with, and thus work could be carried on throughout the whole year with very little protection.

It is suggested that reinforced concrete ships of moderate size should be built in the first instance for the Indian coastal trade.

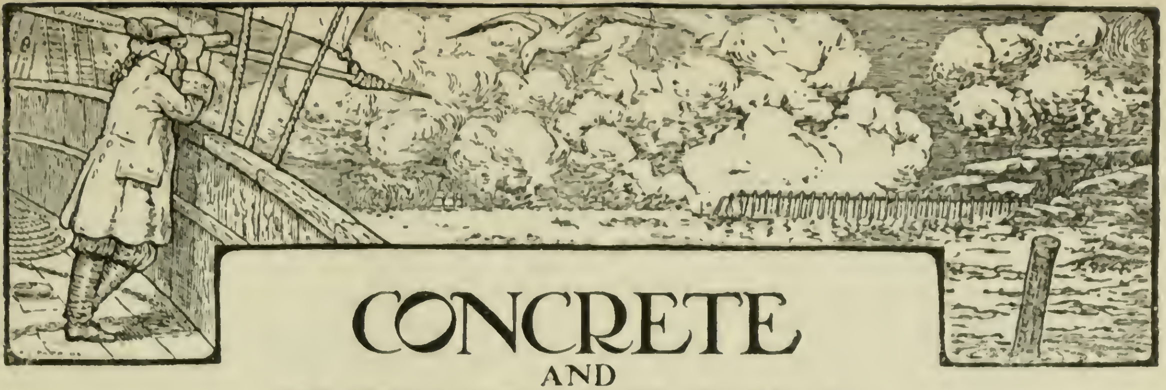
A Reinforced Concrete Barge in South America.—A reinforced concrete barge has just been completed in the Argentine Republic. The barge was built by Messrs. Hume Bros. for their contract with the Ministry of Marine for new concrete wharves in the Arsenal, and is of the following dimensions :—

Length, 25 metres (82 ft. 3 in.).
Beam, 6 metres (20 ft.).
Loaded draught, 1.80 metres (6 ft.), and the
Capacity for river work is about 150 tons of stone or sand.

The barge is self-propelled by one of Messrs. Beardmore's crude oil engines of 20 h.p., supplied by the firm of Banham, which will give it a speed of some 7 miles per hour.

As a precautionary measure Messrs. Hume Bros. subdivided the hull as much as possible, and to this end the sides consist of double walls separated by a space of 3 ft., and there are also two bulkheads completely closing off the bow and stern compartments. The boat is thus practically unsinkable, unless almost cut in half by a collision. The launching was effected sideways.

We understand this barge is only one of many which the above firm has under construction.



CONCRETE
AND
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"CONCRETE SHIPBUILDING"

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REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER IV (*continued*).

DESIGNING CONCRETE VESSELS.

THE system of construction used by the Société Entreprise Générale d'Etudes is more generally known as that of C. A. Roux, the arrangement being shown in *Figs.* 87, 88, 89 *and* 90. The principal member is calculated as a beam with an exceptionally high factor of safety $\left(\frac{PL}{20}\text{ instead of }\frac{PL}{30}\right)$, but otherwise there is nothing very unusual about the designs.

D. Wilson's patent (Eng. Pat. 16,530—1887) relates to single-hulled vessels. For a barge of a carrying capacity of about 100 tons he specifies a frame of iron bars or hoop iron about $\frac{1}{8}$ in. thick and 1 in. wide interlaced or otherwise suitably connected for the reinforcement and a coating of cement or concrete of such depth as to make the entire thickness from surface to surface about 2 in., but the coatings at and near the keel and stern and other angular portions of the vessel are made somewhat thicker than at other parts.

In the arrangement (*Fig.* 91) patented by E. B. Shipley (Eng. Pat. 2,376—1910) the deck 2 is supported by and tied to the bottom 1 and sides of the vessel by a series of reinforced partitions 7, the reinforcement 8 being placed uniformly throughout the deck, the bottom and walls. Both sides of the reinforcement are plastered with concrete and, after the walls have properly set, the centering used to give added strength during the plastering is removed through an opening in one of the partitions and through a similar opening in the deck 2.

In the vessel illustrated in *Figs.* 92-95, and built on the Hennebique system, the reinforcement consists of longitudinal and transverse bars, spaced respectively 4 ft. and 5 ft. apart, the lower ones being pierced with 2 ft. holes to permit the free circulation of the water to the pumps.

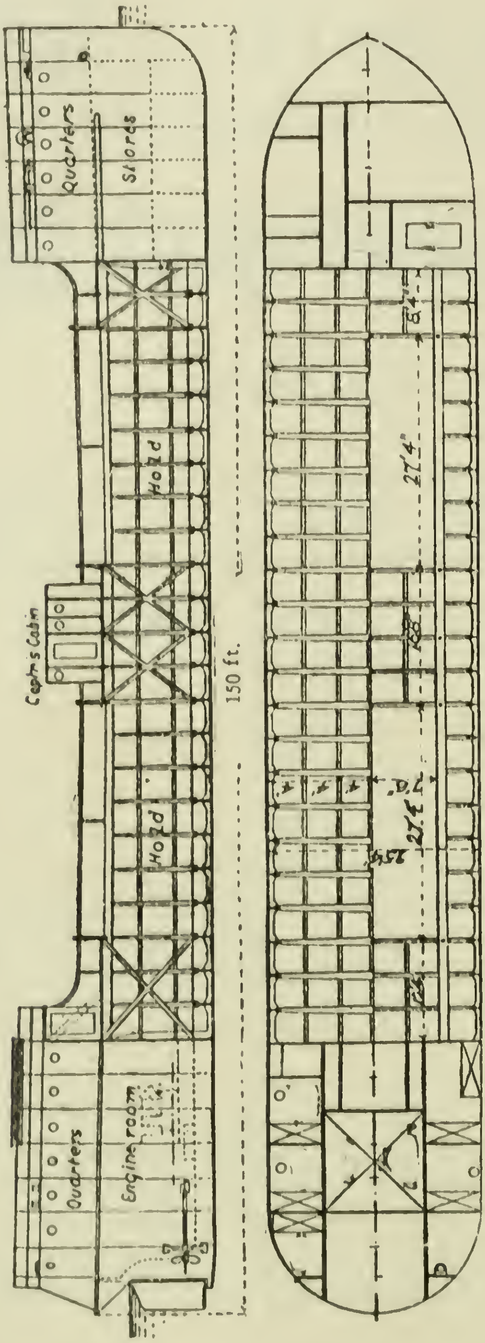


Fig. 87. Section and Plan of Concrete Cargo Boat (Roux System).

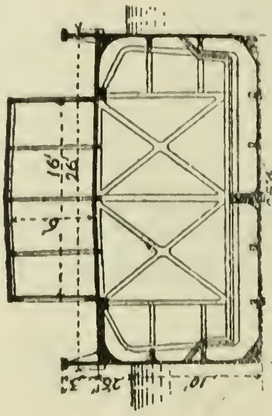


Fig. 90. Section of Fig. 87 through Captain's Cabin on couple 18.

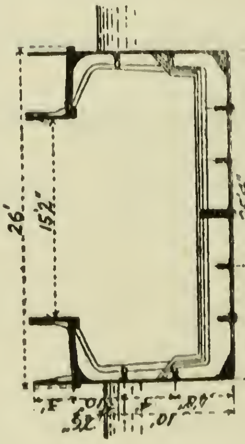


Fig. 89. Section of Fig. 87 through Hold on couple 32.

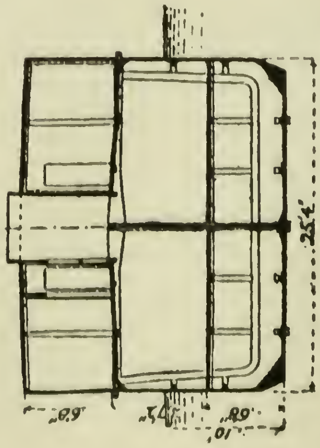


Fig. 88. Section through Engine-room on couple 32.

The concrete shearing and flooring timbers are 2 ft. 8 in. wide and 4 in. to 8 in. thick; the hull is 4 in. thick.

The hull of the vessel is of dense concrete, with two coats of coal tar, applied whilst hot. The deck is faced with about 1 in. of cork powder mixed with a magnesium oxychloride cement.

In constructing vessels on the Hennebique system it is assumed that the hull will take all inclinations up to 30° on any tack. The various elements of the loads are fixed by the assumed weights of the different accessories and the reinforcement. The *wing-transoms* and *carlings* are calculated for an internal pressure of 1,000 lb. per sq. ft., without making any allowance for their own weight or that of the cargo.

The *floor timbers* are calculated to allow for each of the following: (1) Sub-pressure of 1,000 lb. per sq. ft. deducted from the weight of the shell and half the load; (2) sub-pressure of 300 lb. per sq. ft. deducted from the weight of the shell plus the total load carried.

The *riders* are calculated to allow for (1) an external pressure of 1,000 lb. per sq. ft. without any internal pressure, and (2) an internal pressure of 500 lb. per sq. ft. without any external pressure. In the water-tight compartments it is assumed that the partitions are strong enough to withstand the pressure of the bulkhead when full of water.

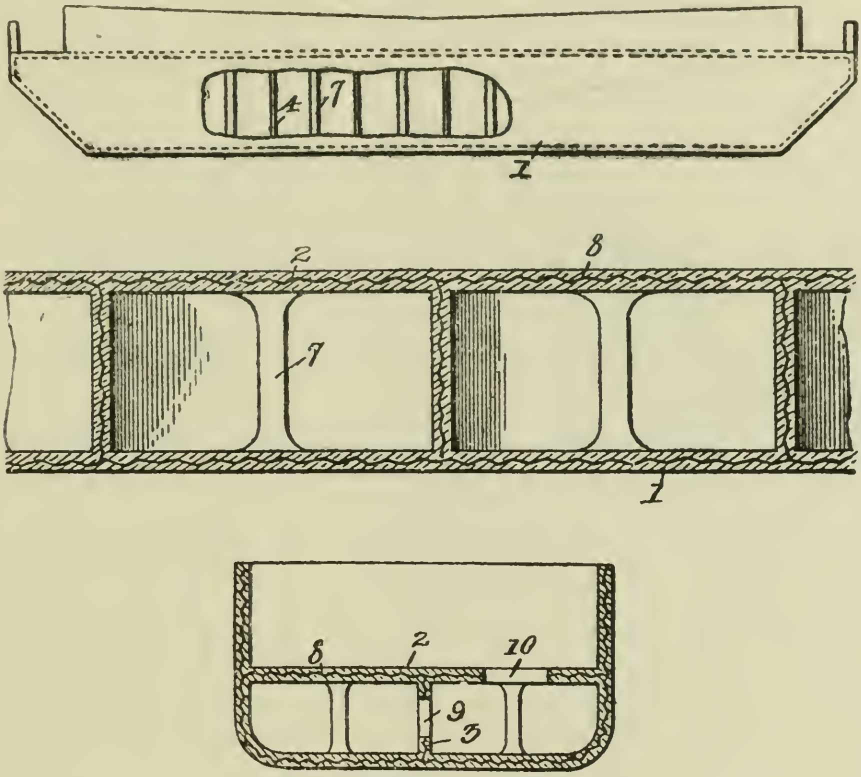


Fig. 91. E. B. Shipley's arrangements.

The *upper deck* is designed to support an overload of 500 lb. per sq. ft. more than its own weight, assuming that the hatches are loaded to 1 ton and transmit this load indirectly to the supporting beams.

It is also assumed that the hull, when lifted on the crest of a wave, is submitted to a maximum moment of flexion $\frac{PL}{30}$ (either positive or negative) in which L is the length of the vessel between perpendiculars and P the total weight of the fully loaded vessel. The section of the longitudinal reinforcement calculated to resist this stress is maintained constant on the central half of the length of the vessel, and is gradually reduced towards the ends, where it is taken at only one-quarter of its maximum value.

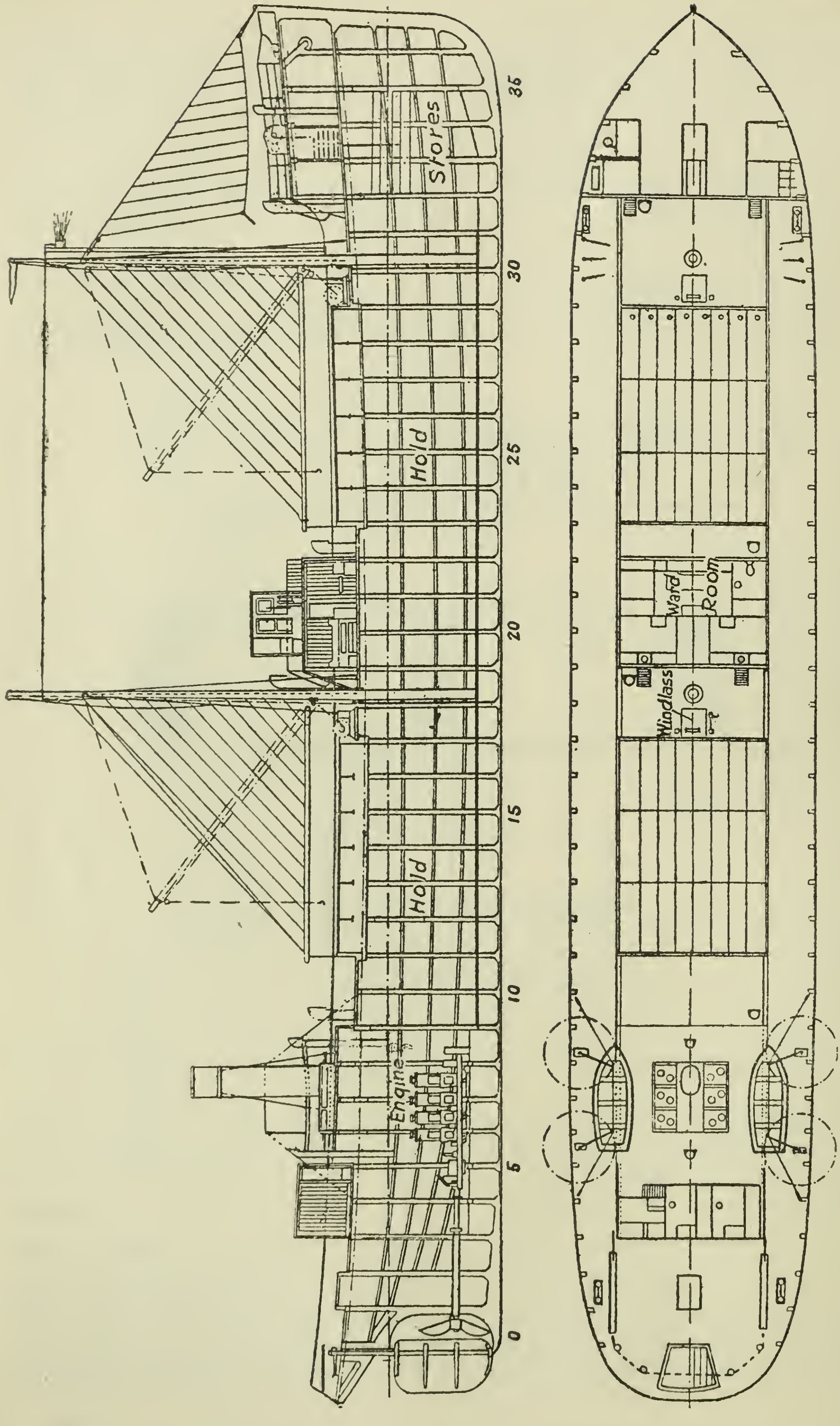


Fig. 92. Section and Plan of Concrete Vessel (Hennebique System).

The maximum shearing stress is taken as $\frac{P}{7}$ on the central three-quarters of the length of the vessel.

A longitudinal torsional couple up to $\frac{PL}{20}$ is allowed.

The reinforcement is made sufficiently strong to allow the vessel to rest on its keel or partly on its side and its keel on the beach or in a dry dock without any other support.

E. Lee Heidenreich, Kansas City, Mo., prefers a double shell (*Fig.* 96) built on five vertical longitudinal trusses, three longitudinal horizontal trusses consisting of one deck and two floor trusses and a series of transverse bulkheads pierced by openings of any convenient size. The two shells are tied together with numerous "spacers," both shells and spacers being reinforced by steel rods arranged uniformly and covered with wire netting. The chief feature of his arrangement is not in the reinforcement, but in the use of sliding moulds.

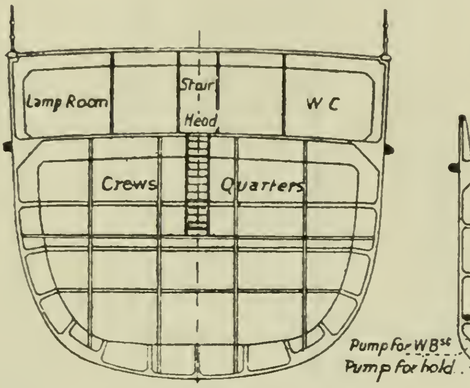


Fig. 93. Section of Fig. 92 on 6th couple.

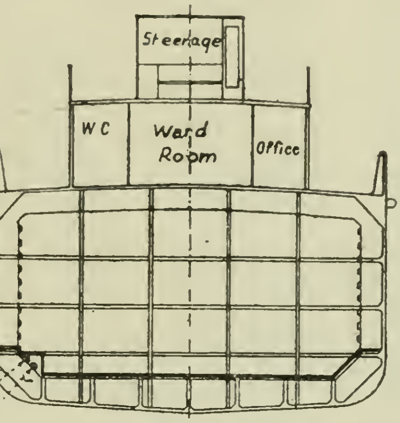


Fig. 94. Section of Fig. 92 on 21st couple.

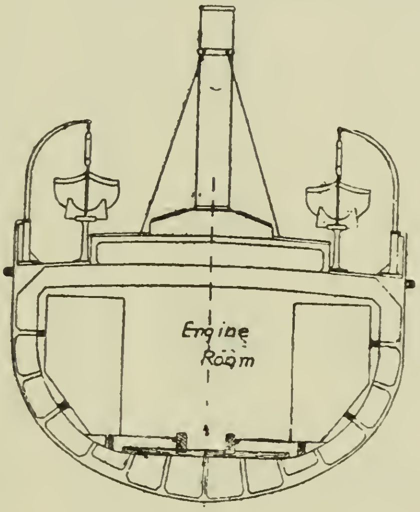
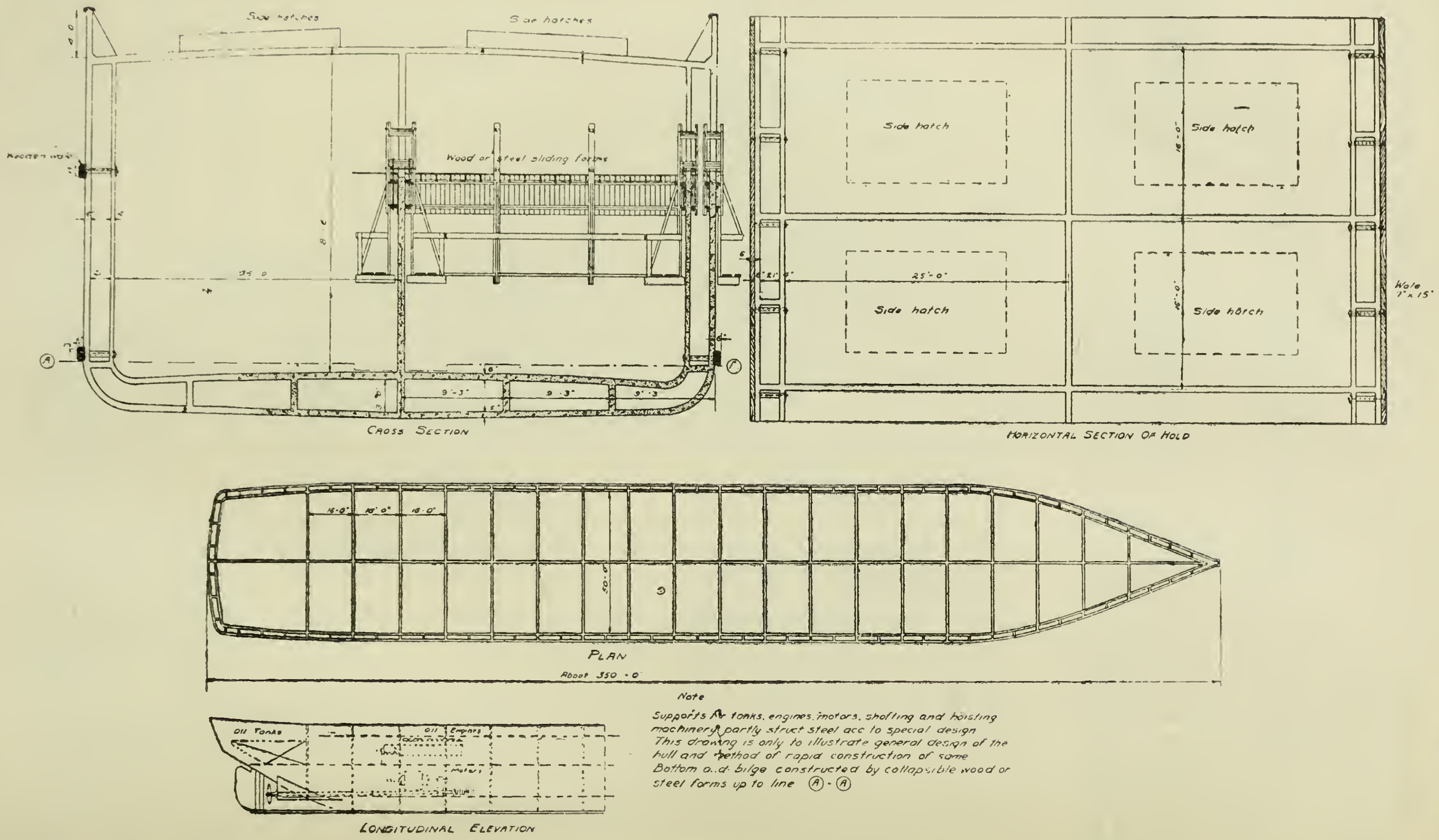


Fig. 95. Section of Fig. 92 on 32nd couple.

Allen Hoar, of Alameda, Cal., also prefers a double shell, but the space between the two portions is more open than in the arrangements previously described. The disposition of the reinforcement is clearly shown in *Fig.* 97.

The barge designed by A. A. Boon, of Amsterdam, and illustrated in *Figs.* 9 (see p. 9) *and* 98, also has a double shell, the outer portion being composed of a large number of steel bars spaced uniformly and the inner one of wire netting. Both the



Note

Supports for tanks, engines, motors, shafting and hoisting machinery, partly struct steel acc to special design
This drawing is only to illustrate general design of the hull and method of rapid construction of same
Bottom and bilge constructed by collapsible wood or steel forms up to line Ⓐ - Ⓐ

Fig. 96. Concrete Transports as proposed by E. Lee Heidenreich.

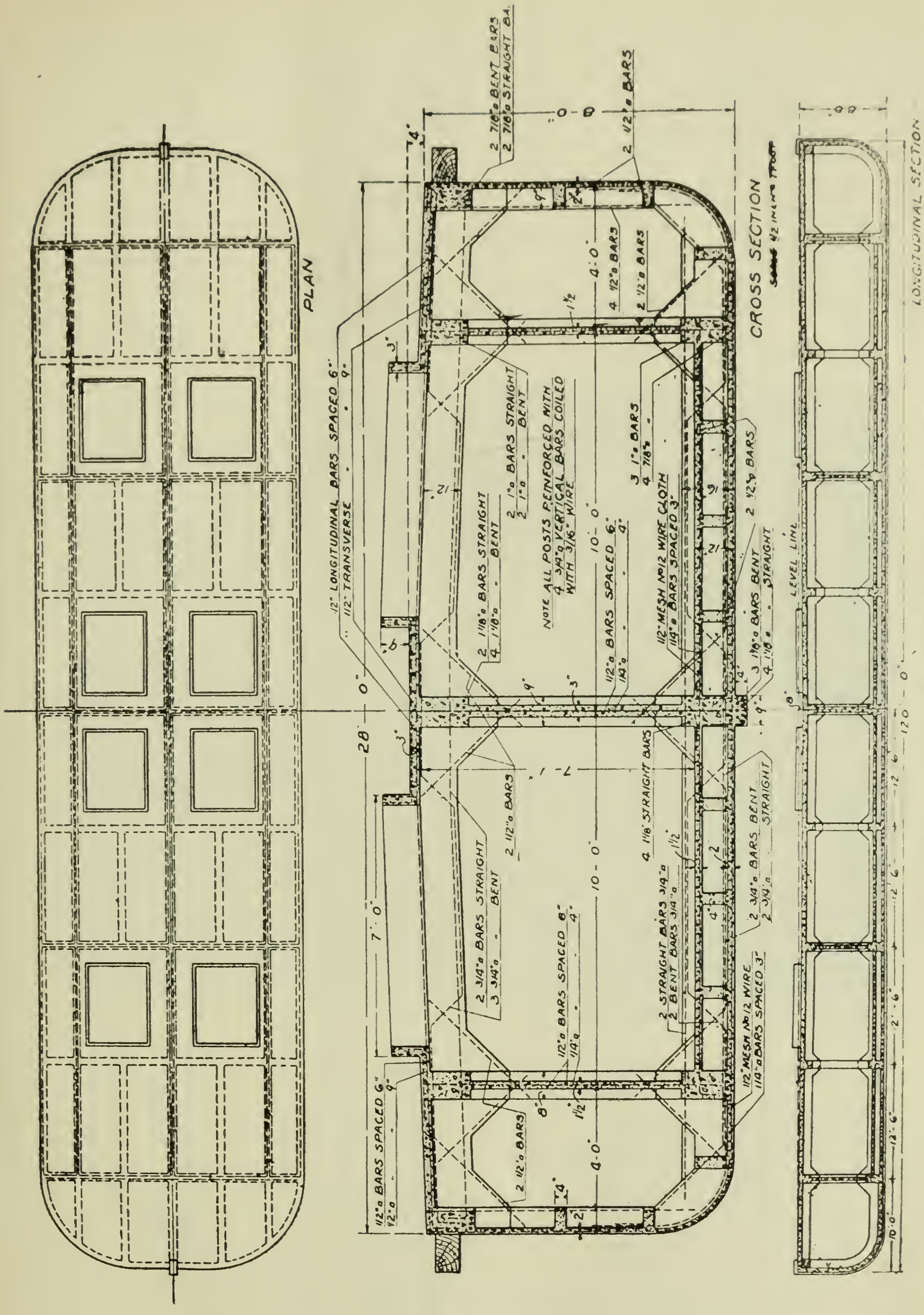


Fig. 97. Design for Reinforced Concrete Barge proposed by Allen Hoar.

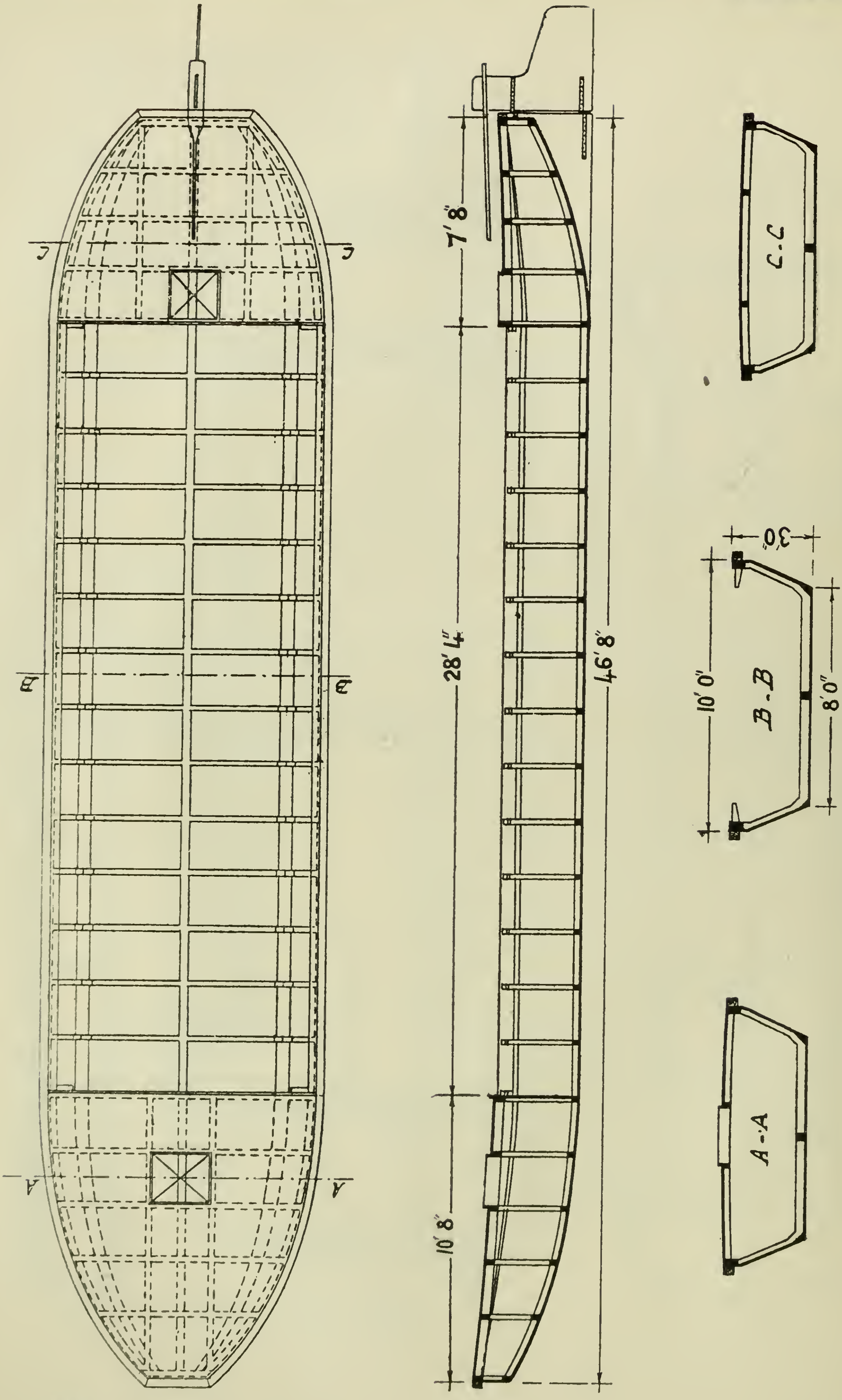


Fig. 98. Details of Barge for ashes and mud. (A. A. Boon.)

inner and outer shells are securely tied to each other by numerous "spacers," and the whole vessel is stiffened by a transverse bulkhead placed fore and aft.

An arrangement patented by H. E. Smith, of Boston (U.S. Pat. 1,090,349), consists of a hull with an outer shell 5-7 in. thick and an inner shell 4-5 in. thick. The two shells are separated by concrete spacing pieces (forming small watertight compartments), and also contain an arrangement of interlaced steel rods to dissipate the force of any violent shock or explosion. Hence Smith's patent bears a very close resemblance to the other arrangements of this type, and the patent specification does not show any special advantages over the others.

It is now generally agreed that double shells are not so advantageous as was formerly supposed, and that bulkheads arranged to divide the vessel into a small number of relatively large watertight compartments, each accessible only through the hatches, are more satisfactory. This arrangement also avoids the inconvenience of using longitudinal ribs in the hold, the larger partitions or bulkheads not being so much in the way.

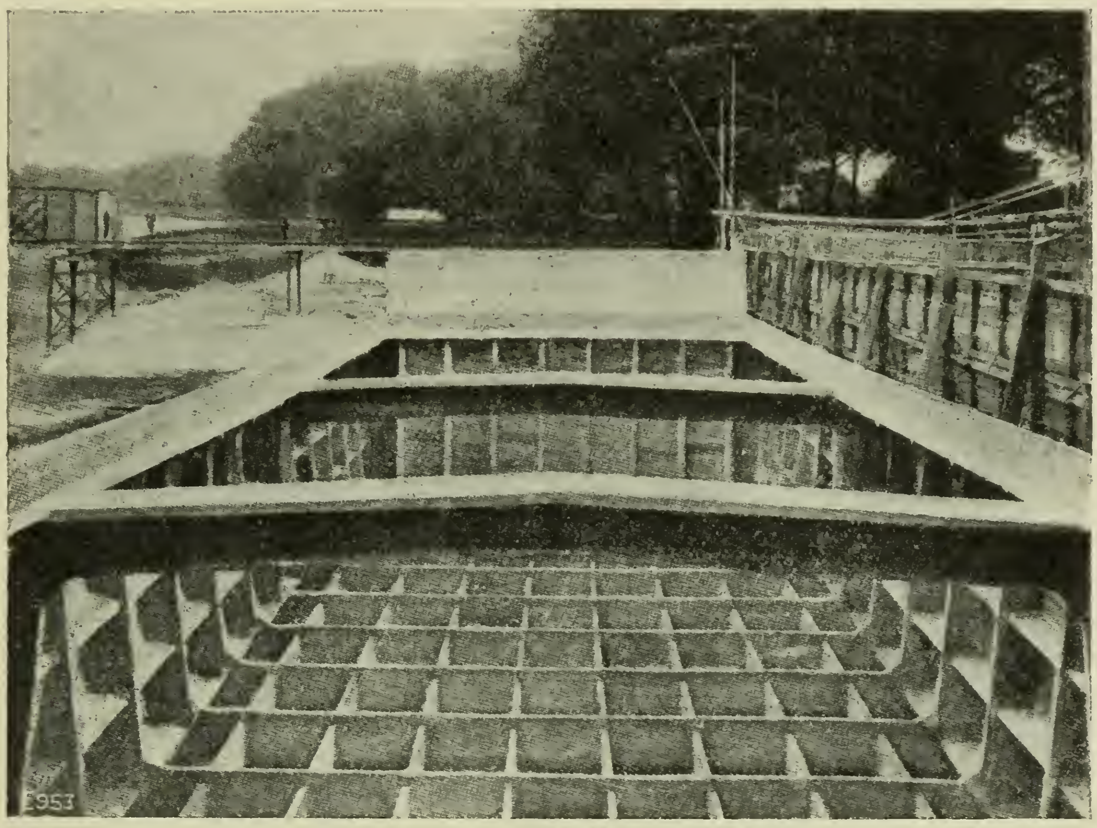


Fig. 99. Interior of Concrete Vessel (Lorton System).

The honeycombed structure shown in *Fig.* 99 possesses great strength and resistance to external pressure and is employed in a considerable number of concrete vessels, though the present tendency is to reduce the number of horizontal portions and to convert the cells (usually about 2 ft. square) into long rectangular troughs.

The "honeycomb" was extensively used by Gabellini in Italy, who constructed a reinforcement of round steel rods, covered externally with $\frac{1}{4}$ in. mesh wire netting or expanded metal of appropriate gauge (*Figs.* 100 *and* 101) and plastered this with concrete. The ribs and keel were afterwards formed by means of further reinforcement, so arranged that the pockets are about 10 in. deep and their walls about 2 in. thick. In some instances the pockets are covered with wire netting or expanded metal, which is afterwards plastered with cement, thus converting the honeycomb structure into a double shell.

The arrangement of reinforcement which appears likely to be most extensively used in the future, both for small and large vessels, is a modification of those illustrated in the following pages, a few existing ships being taken as representative of the developments which are now occurring in this branch of shipbuilding.

Carl Weber, of Chicago, builds the hull with a series of laminations varying in number and thickness according to the parts of the vessel in which they are used and employs a series of plates and spacing bars, as shown in *Fig.* 102. The chief feature of Weber's system, however, is the application of the concrete in a series of layers applied by air pressure.

In the barges built for the Arundel Sand and Gravel Co., Baltimore, to the designs of O. F. Lackey (*Fig.* 17) the reinforcement consists of iron rods $\frac{1}{8}$ in.-$\frac{1}{4}$ in. diameter woven into a square mesh and stiffened by a series of bulkheads which divide the hull into twenty compartments, each entered through a hatchway on deck. The bulkheads are 6 in. thick and further support for the deck is given by a series of pillars 6 in. square. The resistance to shock and sudden loads was tested by dropping 6 tons of stone suddenly into the hull; no damage was done and the barge was at once put into active service and has continued so ever since.

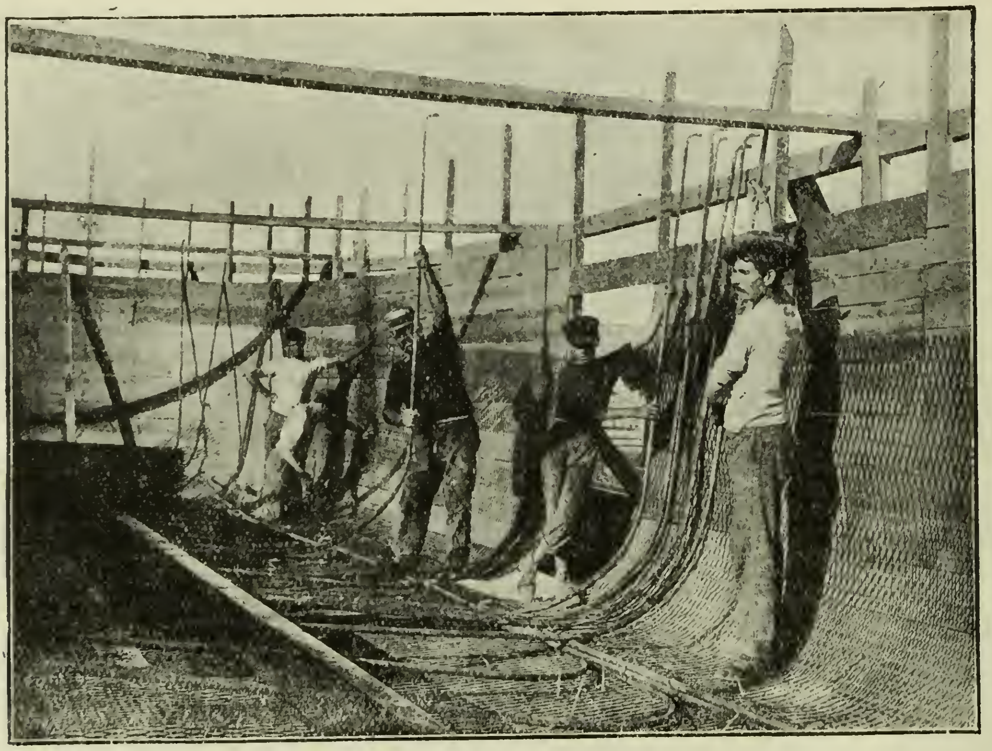


Fig. 100. Concrete Barge in course of construction.

The hull of the barge in use on the Welland Canal, Canada, is divided into eight compartments by means of one longitudinal and three transverse bulkheads. The reinforcement consists of $\frac{1}{4}$-in. steel rods placed 2 in. apart, both longitudinally and transversely, and of 6 in. by 8 in. beams on the bulkhead lines, supplemented by posts. The bottom of this barge is quite flat, the sides and ends making with it an angle of 70°.

The reinforcement in the barges built by the Cement-Izer-Werken, Holland (*Fig.* 103), is arranged in a series of longitudinal and transverse bulkheads on 6 ft. centres and tied into the reinforcement of the shell.

A 60-ton lighter (*Fig.* 8) built by A. A. Boon, of the same firm, is divided into compartments by three large and thirty-three transverse bulkheads (*Fig.* 103), served by four double hatchways, the arrangement of the steel rods being shown in *Figs.* 104 and 105.

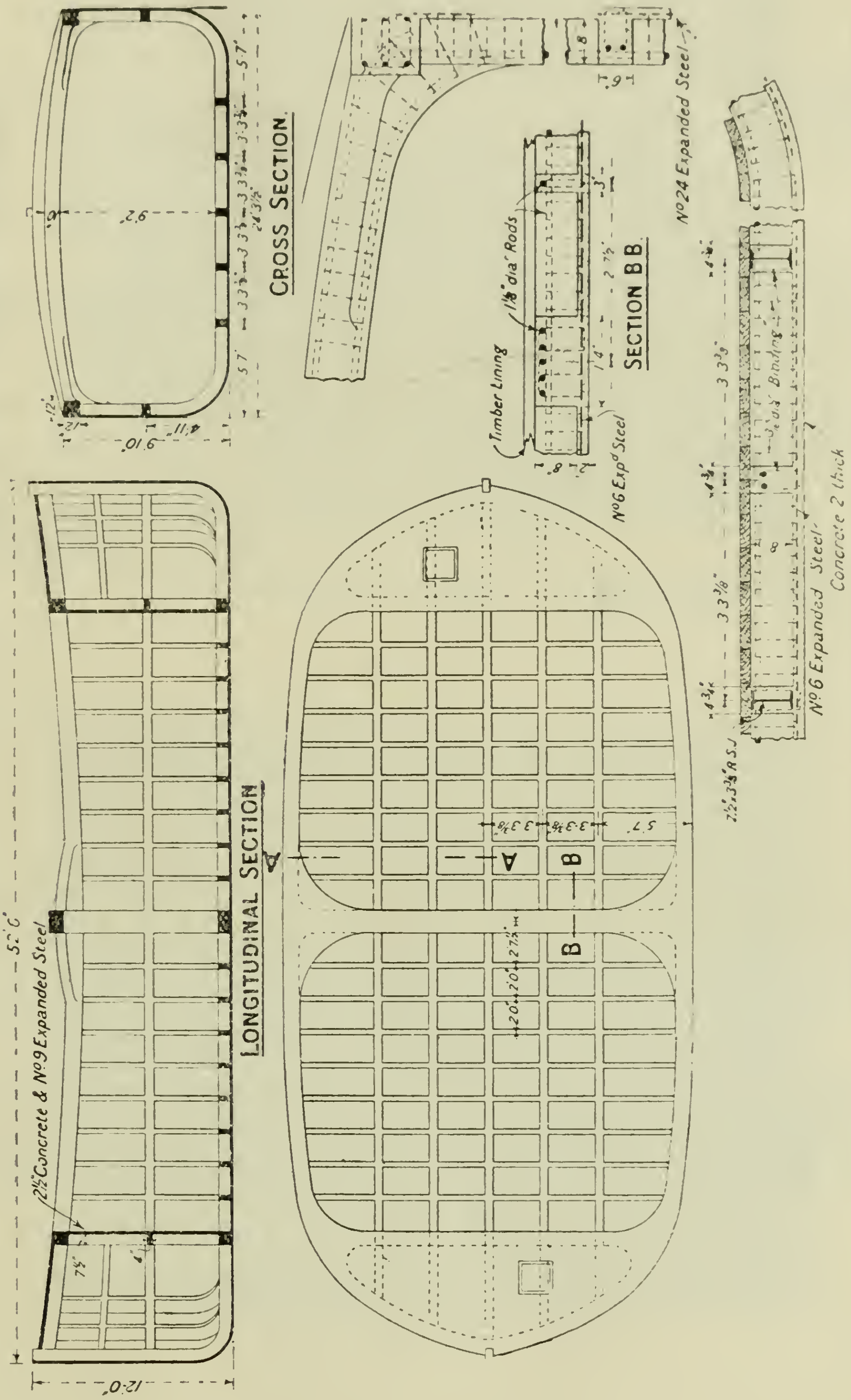


Fig. 101 Concrete Barge, showing Application of Expanded Steel

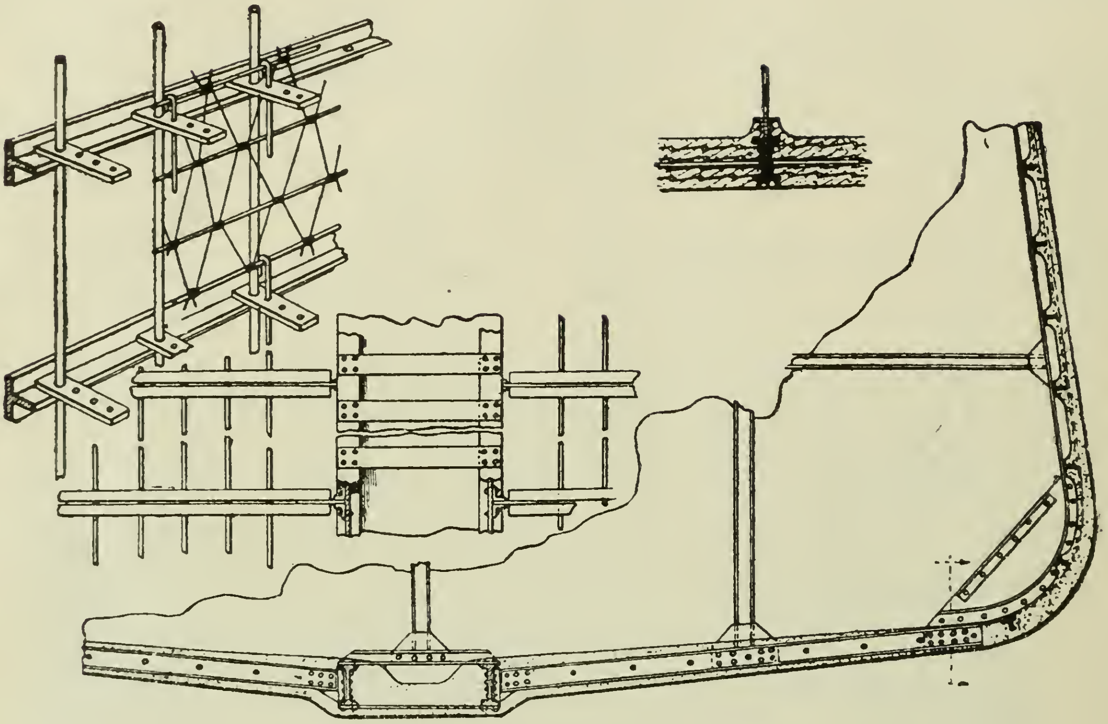


Fig. 102. Details of Design of C. Weber.

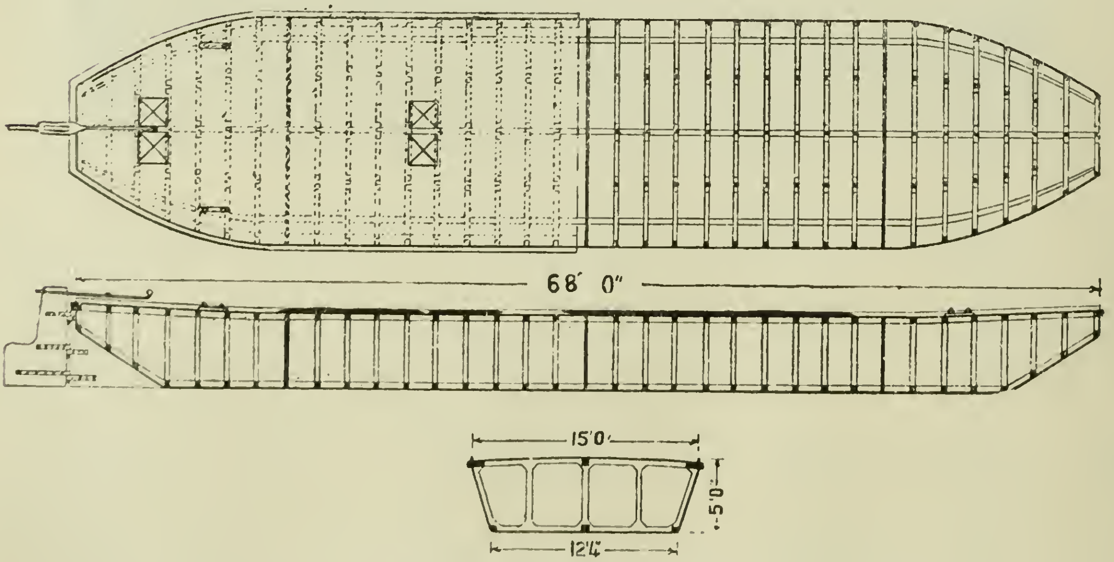


Fig. 103. Details of a 60-ton Lighter.

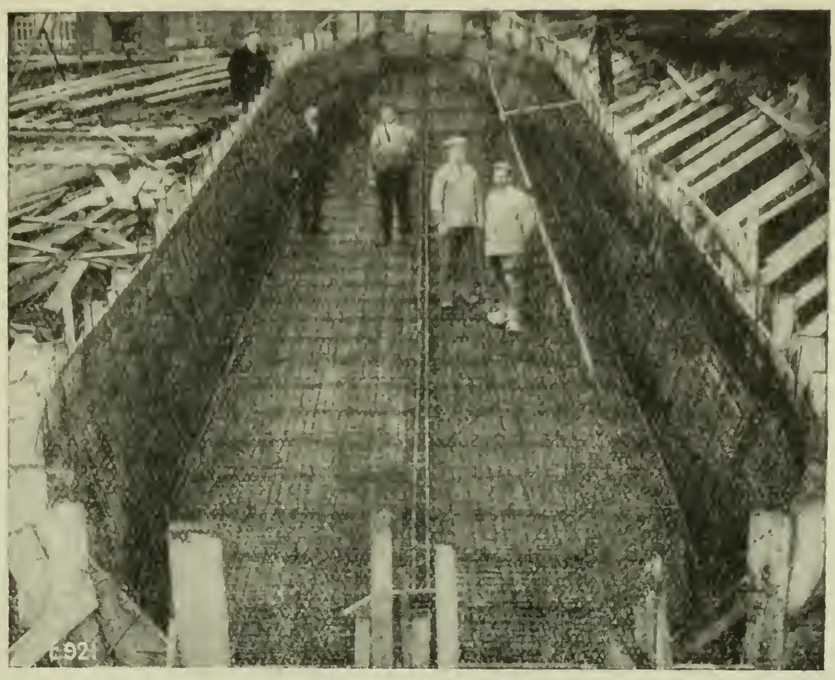


Fig. 104. Main Reinforcement of 60-ton Lighter.

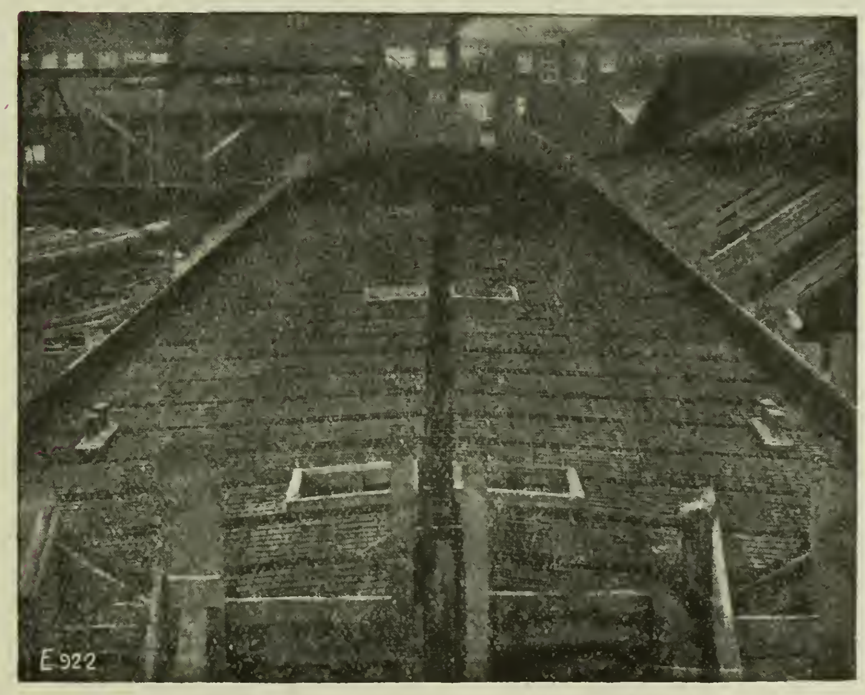
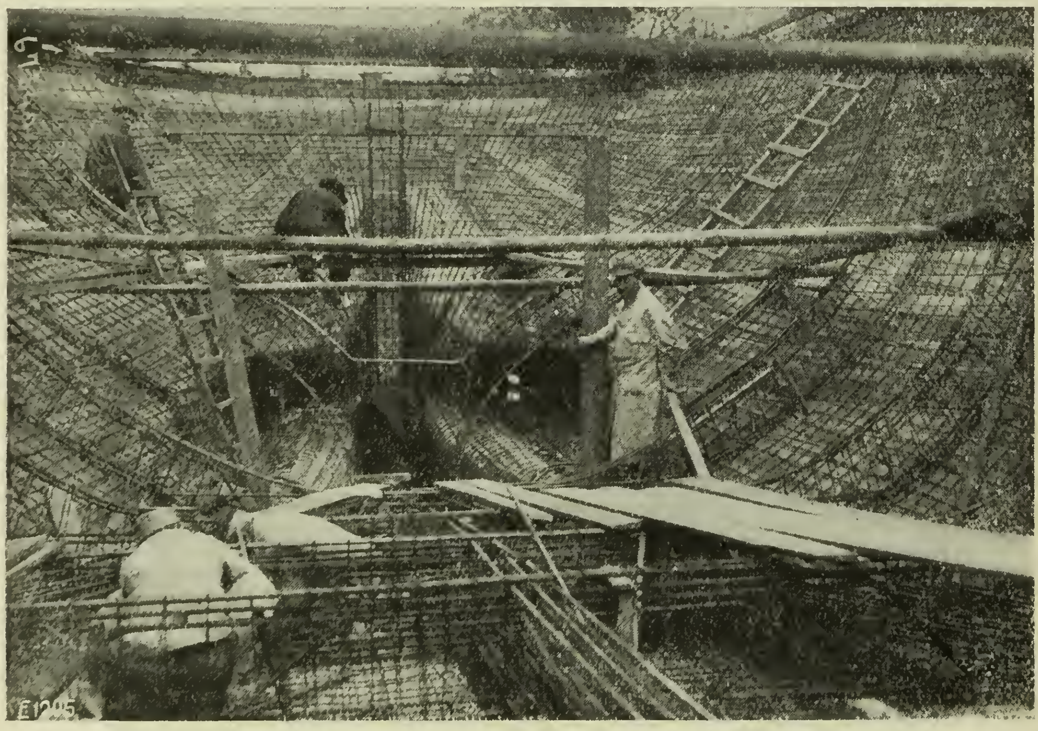


Fig. 105. Deck Reinforcement of 60-ton Lighter.

FURTHER PROGRESS IN CONCRETE SHIPBUILDING IN FRANCE.

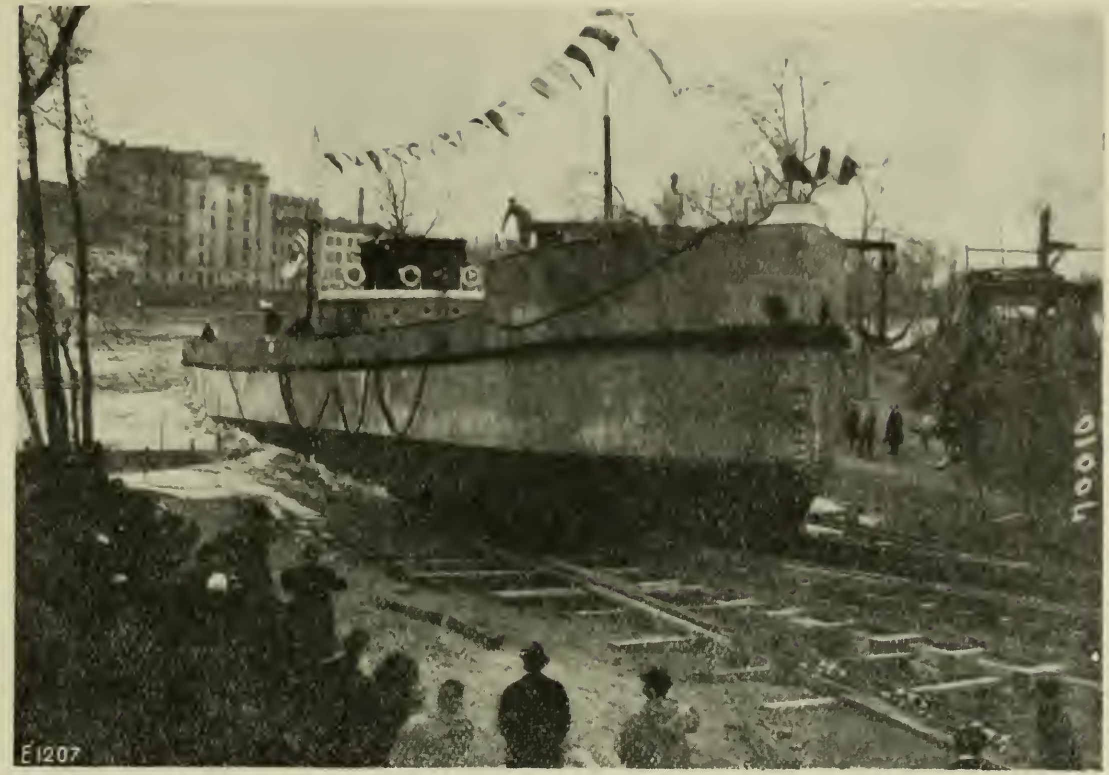
THE "COMAFRAN I."

DURING the last year considerable progress has been made in constructing concrete ships at Neuilly-sur-Seine, where the first motor-driven seafaring boat built on the Roux system for the coal trade between Rouen and this country of the Cie Maritime France-Anglaise, was launched on December 29th last. This vessel —*Comafran I.*—has a displacement of 965 tons, is 150 ft. in length, 25 ft. wide, and is driven through twin screws by a Panhard & Levassor motor of 120 h.p. at a speed of eight knots. The hold is in six water-tight sections, of which the first is for the stairway, the second for the stores, the third and fourth for the cargo, the fifth for the engines and fresh water, and the sixth for fuel. The men's quarters are above board.

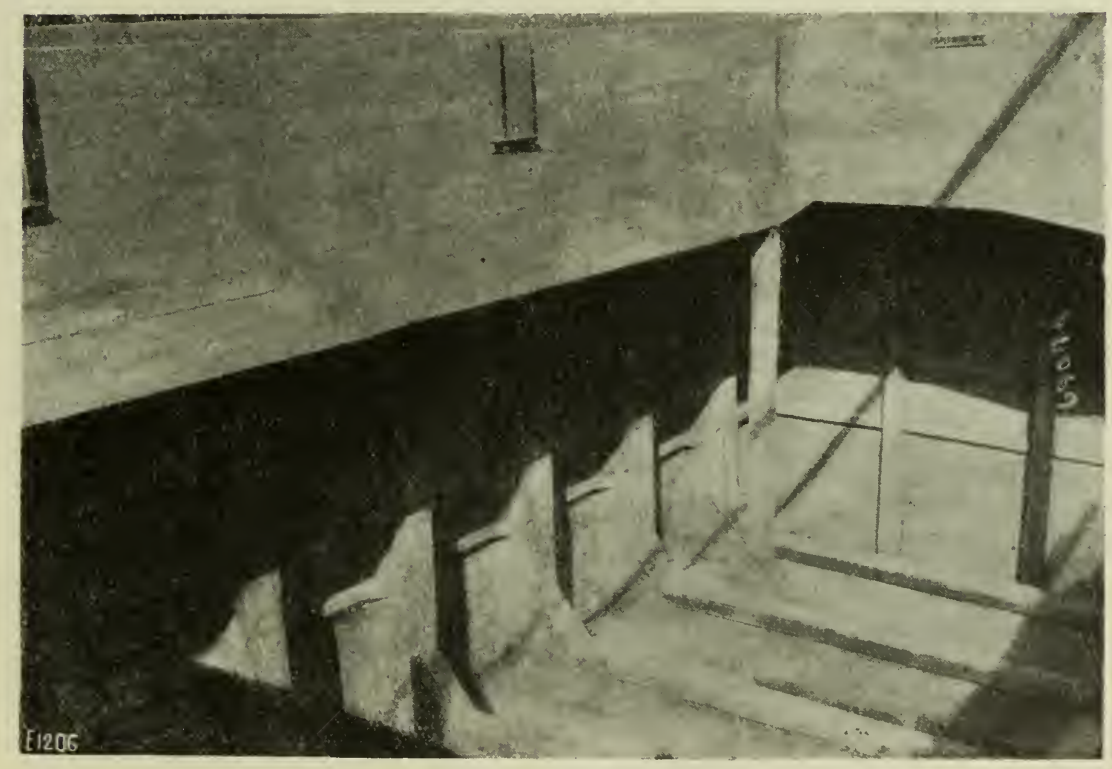


Reinforcing the stem of *Comafran I.*

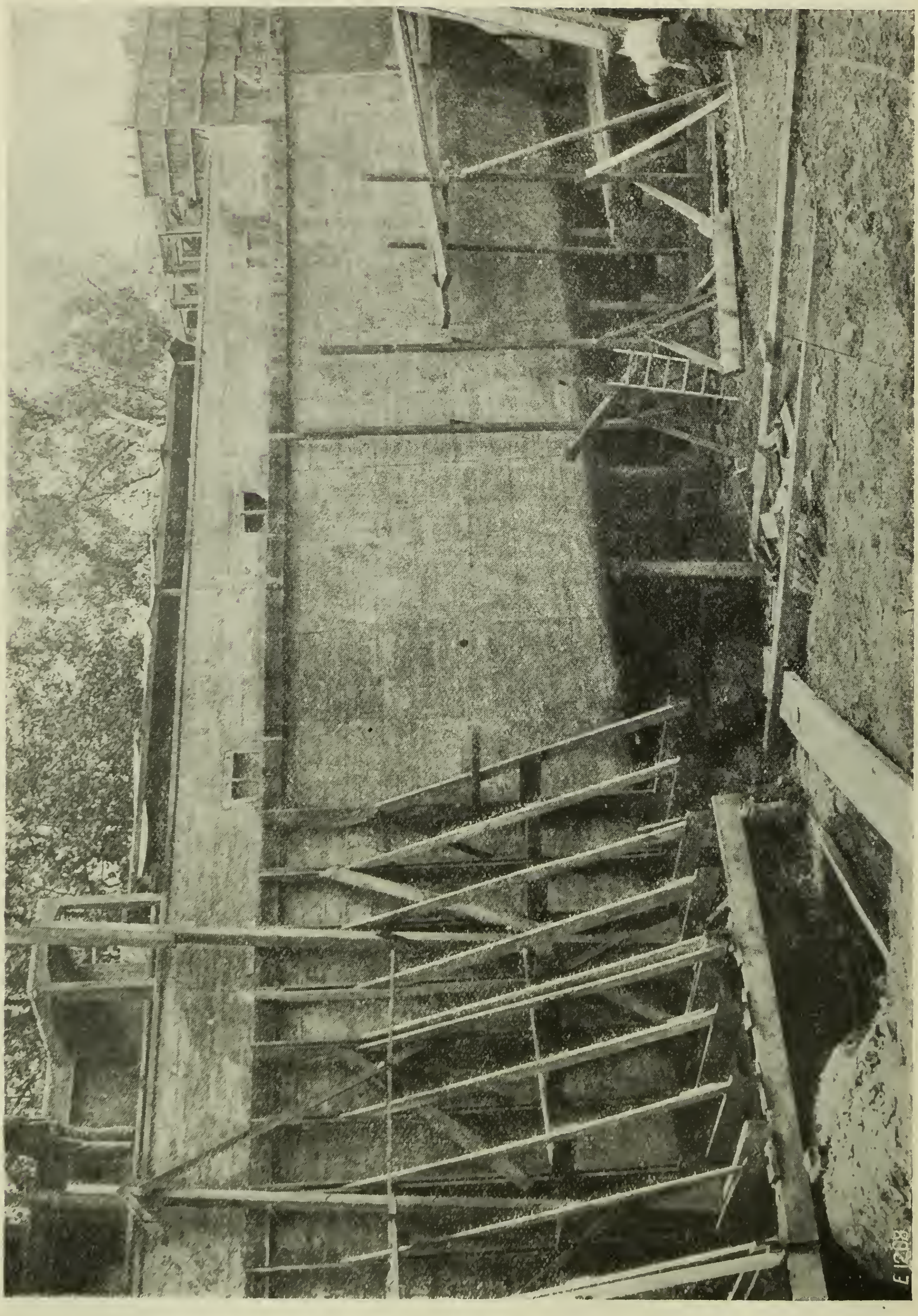
The hull is designed in conformity with the rules of the Bureau Veritas for concrete vessels. The interior is protected by an oak fender placed above the deck. The bottom of the cargo-holds is protected by a floor of pine or oak, which extends part of the way up the sides. The remaining features are those normal to modern vessels for the class of trade to which this vessel is intended, though an attempt has been made to provide greater comfort both for the officers and men than is usually the case.



Launch of the *Comafran I.* near Paris.



Part of interior of *Comafran I.*



Removing the shuttering from *Comafran I.*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

"CONCRETE SHIPBUILDING"

A Monthly Supplement

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MAY, 1919
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REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER IV (*continued*).

DESIGNING CONCRETE VESSELS.

The arrangement of the reinforcement in the shells of the barges built by the Sociedad Construcciones y Pavimentos at Barcelona is shown in *Figs.* 106, 107 and 108.

The method of construction of the concrete barges at Bahia (p. 118), reinforced on the Edmond Coignet system, with straight bars and stirrups, is shown in *Figs.* 109-113, the partitions being $1\frac{1}{2}$ in. thick.

The arrangement patented by N. Fougner (Eng. Pat. 29,938—1912) consists of a number of transverse frames of a suitable section—some of them continuous or ring-like—formed or connected with several longitudinal parallel beams in the bottom, sides and deck, converging at their ends towards the stem and stern posts of the vessel, together with stiffener beams diverging upward from the keel beams to the sides of the vessel, the stem and stern posts being vertical or slightly inclined outward, and water-tight bulkheads at the transverse frames nearest the stem and stern. If preferred, the vessel may have a flat or slightly curved bottom, and the sides may be vertical or curved inward with a curve or bend at the junction with the bottom.

A fender of hard wood runs around the top of the sides.

Fig. 114 shows a half side elevation and half vertical longitudinal section through the vessel, the section being taken on the line 1–1 of the deck plan, shown in *Fig.* 115, together with an end view of the vessel (both ends are alike).

Fig. 116 shows a cross-section of the vessel on the line 2–2 of *Fig.* 114, showing part of a hatch in position ; on the left half of this figure is indicated the construction of a bulkhead arranged at each end.

The distinctive feature of these vessels is that they are constructed on a skeleton frame consisting of four transverse ring-like frames *C* carrying, in the typical lighter illustrated, four keel beams *B* with two beams *F* and *G* on each side. The number of frames and beams required varies with each individual vessel. The two transverse frames *C* at the ends of the lighter are always filled in with a bulkhead.

The bottom of the vessel is composed of the slab *A* and four keel beams *B*. The slab *A* is flat in its central portion, but curved and increased in thickness at its junction with the sides. It is reinforced with rods A^1 near its upper and lower surfaces running transversely to keel beams, while a few light rods A^2 are placed longitudinally in each panel to provide for shrinkage and temperature stresses and prevent cracks on this account, and to provide for all bending stresses.

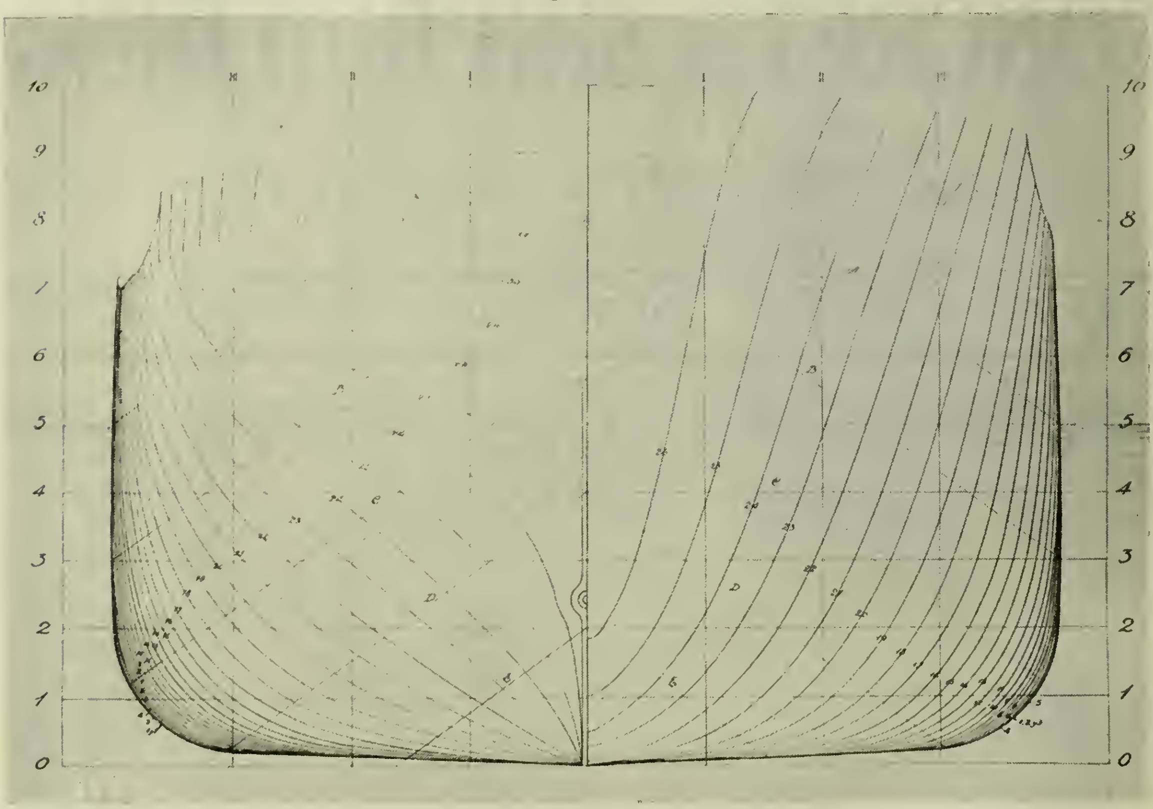


Fig. 106. Details of Design of a Spanish Concrete Boat

The steel rods near the upper surface take up stresses from water pressure, while those near the underside provide for stresses imposed by heavy cargo placed in concentrated loads directly on the bottom slab or thrown against the same.

Over the supporting keel beams *B* the negative bending moments in the slab are provided for in exactly the reverse manner by the reinforcing rods A^1 running straight through, and additional short continuity rods are also inserted between and parallel to the other rods to provide for negative bending moments caused by water pressure.

The bottom of the vessel is perfectly flat in its entire length, but towards both ends the keel beams run together joining in the stem and stern posts, which latter may be vertical or slightly inclined outward, the parts *E* being simply a continuation of the two beams *B*.

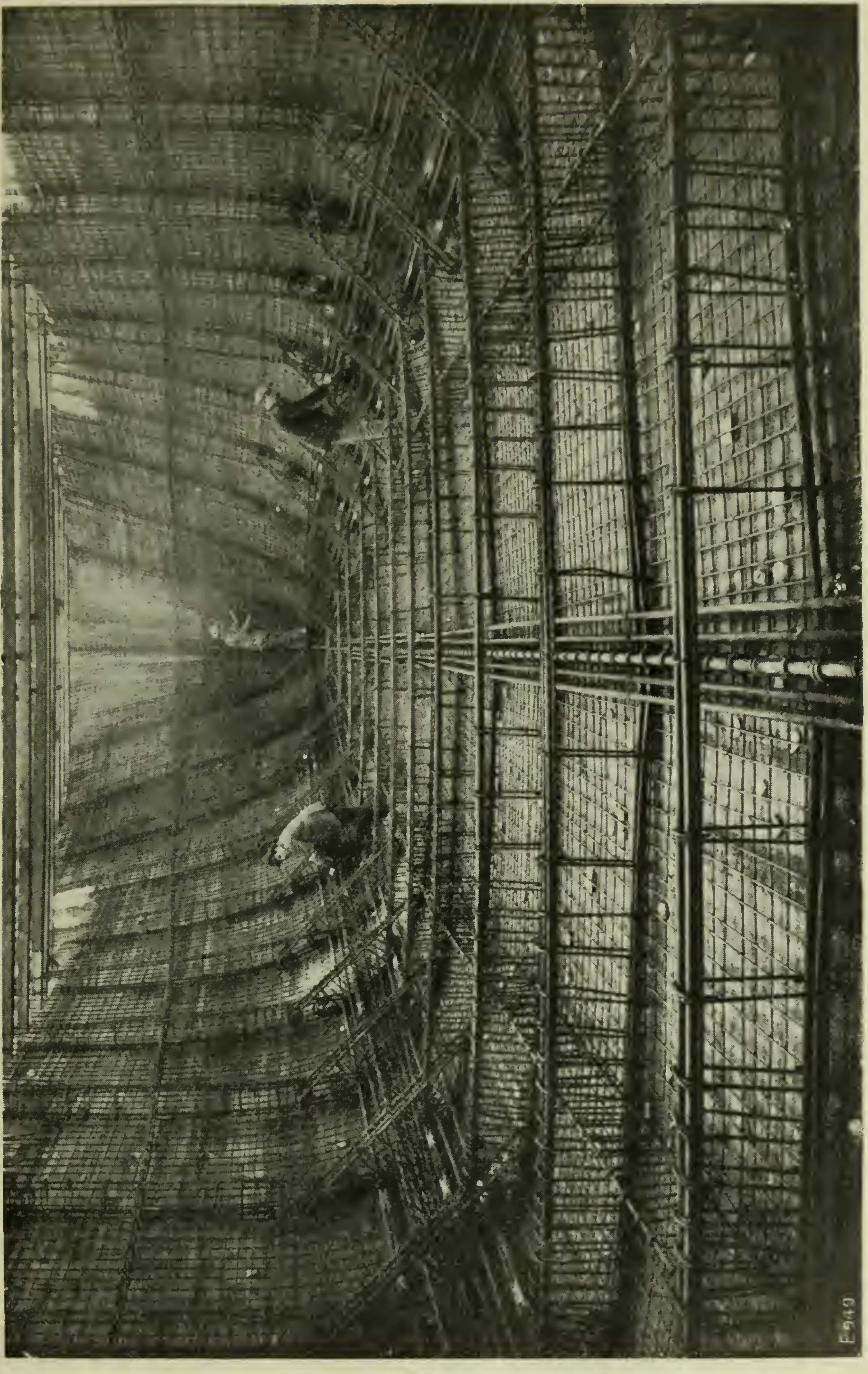


Fig. 107. Internal Reinforcement of a Spanish Concrete Vessel.

All the keel beams *B* are reinforced, both top and bottom, with rods B^1 and the transverse frames *C* are similarly provided with rods C^1 tied together with vertical stirrups B^2 at intervals, and additional short continuity rods (not shown) are provided in beams *B* at the junction with the supporting transverse frames *C*.

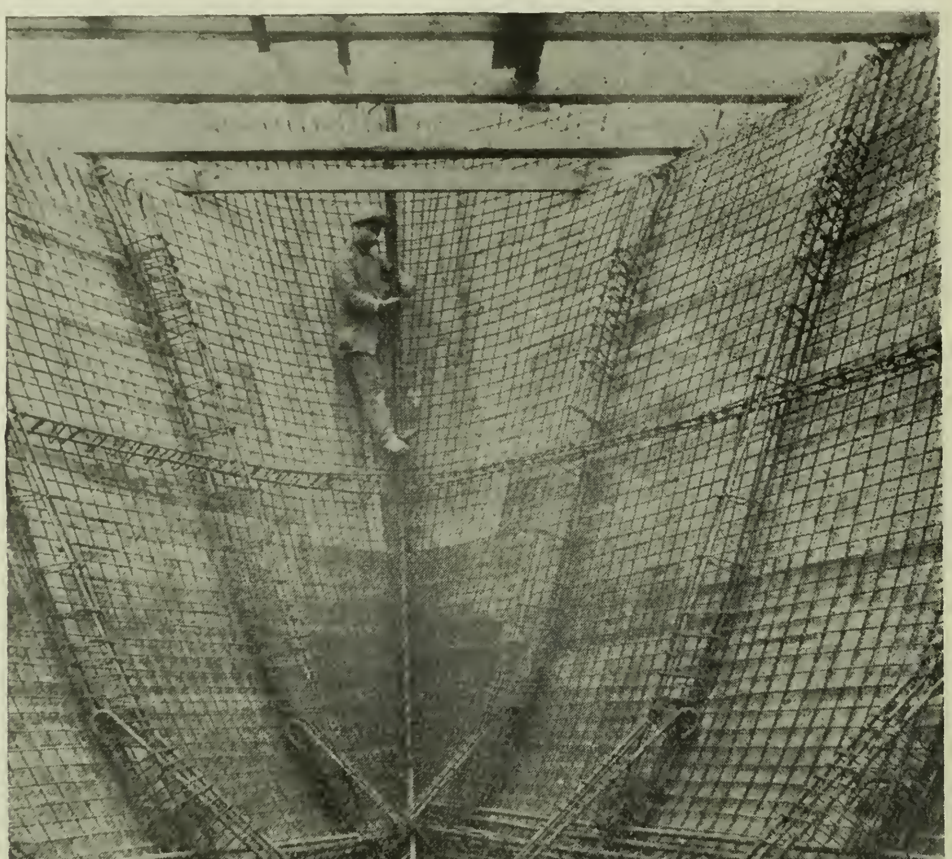


Fig. 108. Reinforcement of Stern of Vessel.

At the junction of the bulkheads, frames *C* and beams *B* and *E*, other beams *D* branch out and extend up on the sides in a curve conforming to the bow and stern of the vessel to act as stiffeners and give greater rigidity in case of collisions and severe strains. They are reinforced both near their outside and inside surfaces similar to the keel beams *B*.

The sides of the vessel are formed by slabs *H* shown in cross-section in *Fig.* 116, and in elevation in *Figs.* 114 and 117.

The main reinforcement runs transversely bearing on beams *F* and *G* near both surfaces with a few temperature and shrinkage rods in the centre of the slab, as shown in *Fig.* 116. Beams *F* and *G* are reinforced on both sides throughout with rods F^1 and G^1 and have additional continuity rods (not shown) at the junction of the supporting frames *C*. In addition to this reinforcement, the deck slabs *J* are provided with a couple of heavy longitudinal rods J^1 placed in the centre of the slab which assist beam *G* in taking up reaction at the top from bending moments of the sides and also in stiffening the vessel. The central portion of the slab constituting the deck *J* on both sides of the large hatchway or well is reinforced at the top with short transverse rods J^2, bent down toward the slabs *H* and bent up into a coaming *K* around the hatchway. This slab *J* is a distinct cantilever and the above rods J^2 are designed to take up all stresses from bending moments caused by heavy loads being placed on the deck *J*.

The coaming K is reinforced with longitudinal temperature rods K^1 and also has a ledge on the inside of its top edge for receiving the hatch or covering *V*.

The deck covering both ends of the vessel between the bulkheads and its extreme ends consists of a slab reinforced transversely in its bottom, resting on the beams *O* and *P*, the latter being reinforced with two sets of steel rods tied together by stirrups made of light wire. This double reinforcement is provided because the beams *O* and *P* act as stiffeners in case of severe shocks and also serve to transmit stresses imposed from towing cables fastened to bollards *T*.

The bulkheads consist of slabs *N* doubly reinforced near both surfaces and designed strong enough to resist water pressure from outside in the event of the bow or stern being damaged

The reinforcing rods N^1 in them run transversely bearing on vertical beams *M* which again frame into the beam *L* at the top and the beam *C* at the bottom as shown. These beams *M* are also doubly reinforced by rods M^1, tied together by wire ties or stirrups M^2 (*Fig.* 116).

In order to resist the side reaction from the bulkheads in case of water pressure the transverse frame *C* at each bulkhead *N* is designed stronger than the interior frames *C*. In section this increase in dimensions is shown in *Fig.* 114 where the top of the frame *C* is called a beam and marked *L*. The underside of the beam *L* forms a straight horizontal line while the upper part of the beam is moulded into one piece with transverse frame *C*. This constitutes an important detail in Fougner's invention ; it allows a heavy reinforcement of rods L^1 to be placed in a straight line in the beam *L* in addition to the curved rods C^1 in the regular frames *C*. The beams *L* (which are actually part of the frames *C*) therefore act as beams turned sideways in order to support the bulkhead *N* at top against eventual water pressure, and the straight reinforcement is placed near both their front and rear faces and tied together with wire. Additional rods are also placed near both sides of the frames *C* at the bottom of the bulkheads *N* for the same reasons.

Fougner has observed that all beams and slabs should be moulded monolithically, that is, in one operation as far as possible. He prefers to make all reinforcements in the beams double, that is, steel is placed in both top and bottom of the beams about 1 in. from the surfaces and tied together with wire. All steel reinforcements in the slabs should be placed about $\frac{1}{2}$ in. away from the surfaces.

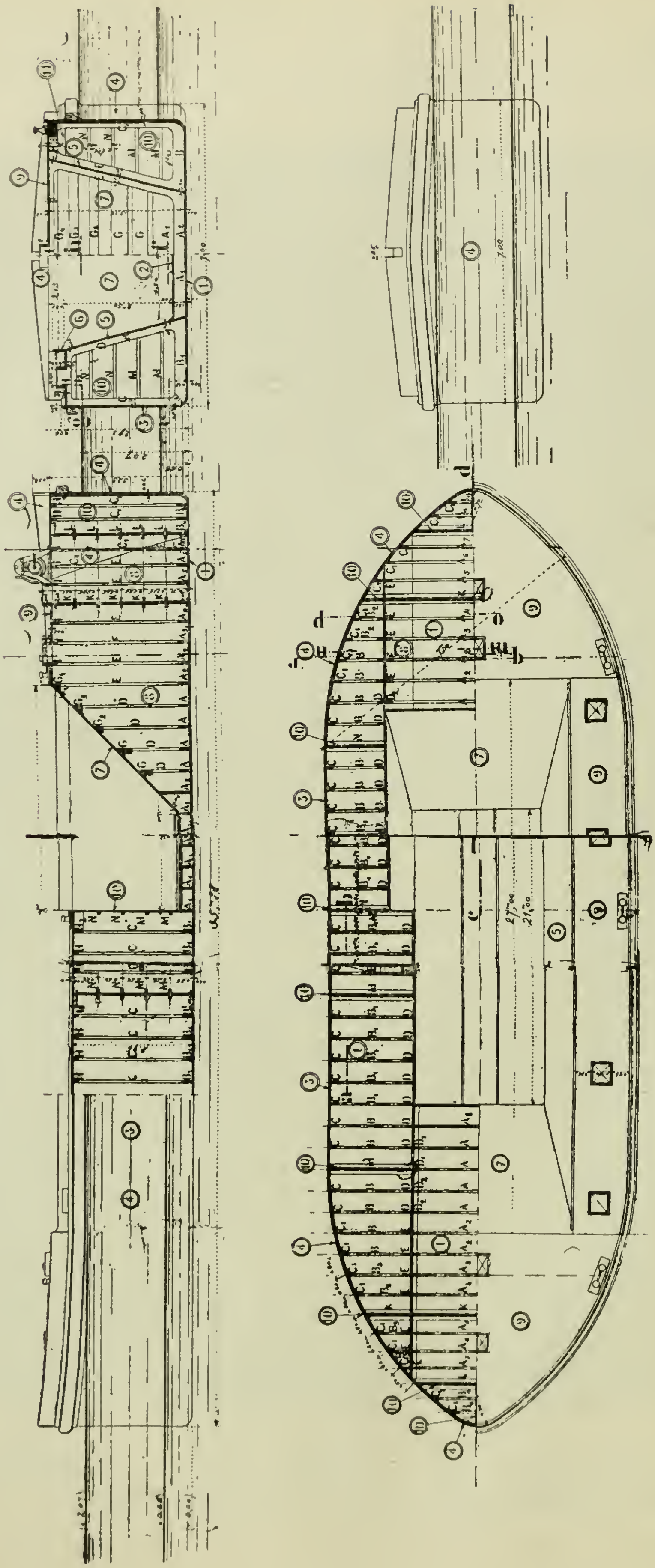


Fig. 109. Part Plan and Section of a 250 m.m. Reinforced Concrete Barge at Bahia.

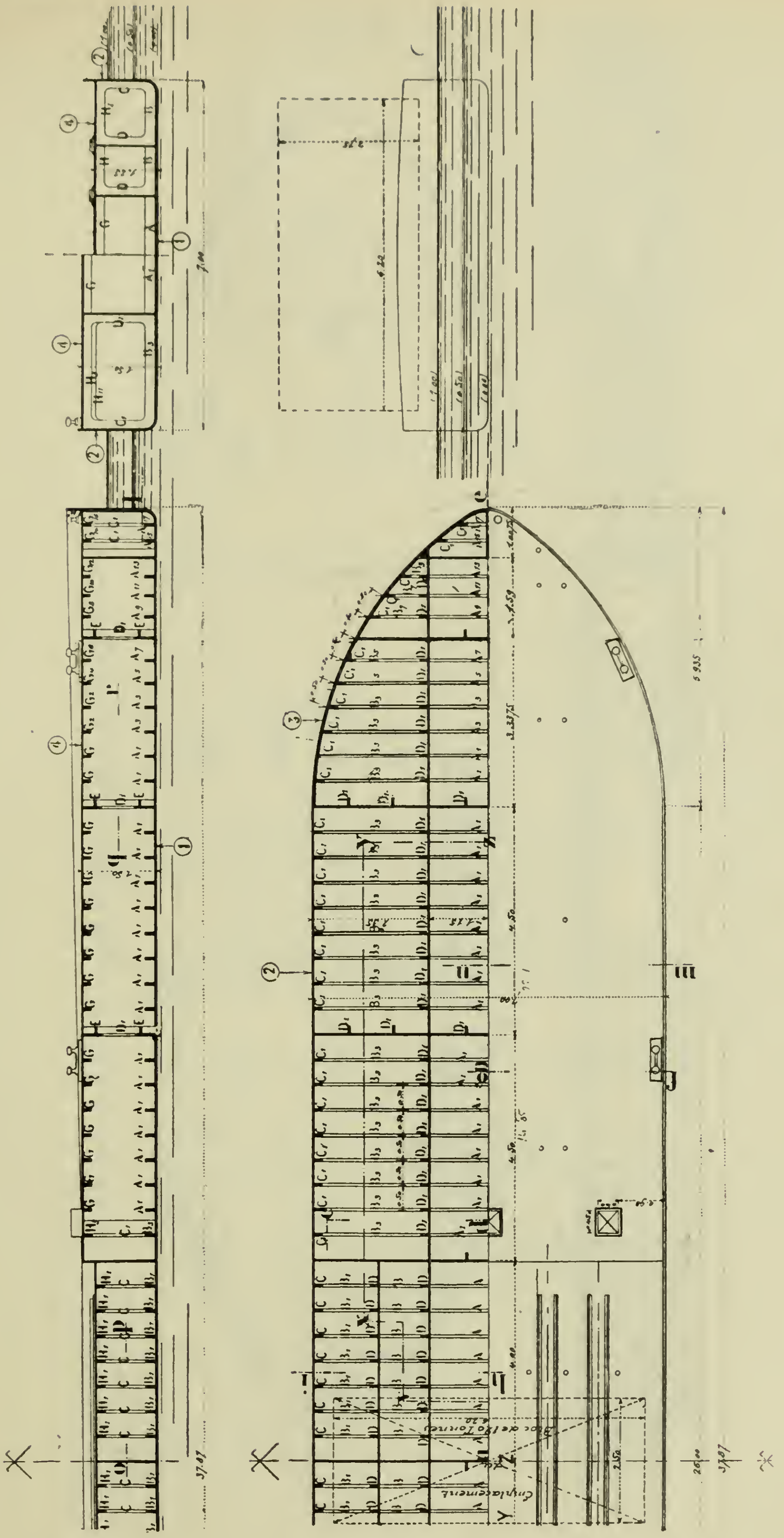


Fig. 110. Part Plan and Section of Barge at Bahia, to carry blocks weighing 120 tons.

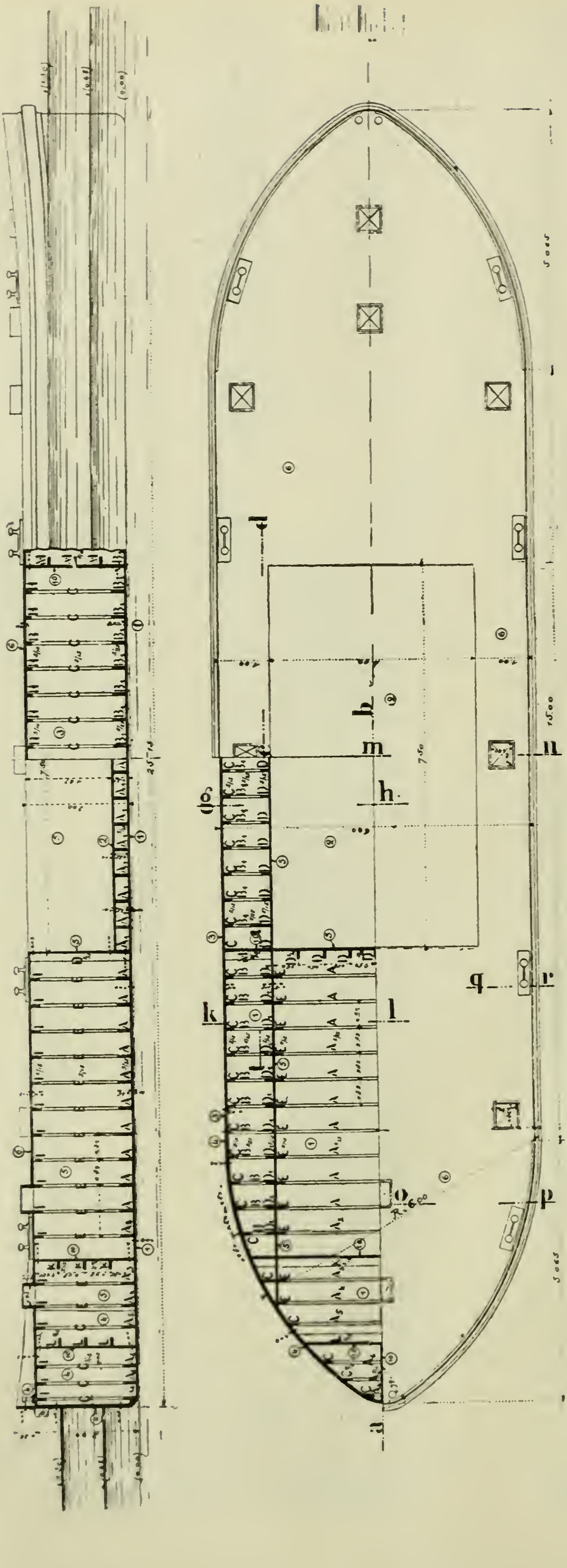


Fig. 111. A 68 cu. yd. Concrete Barge at Bahia.

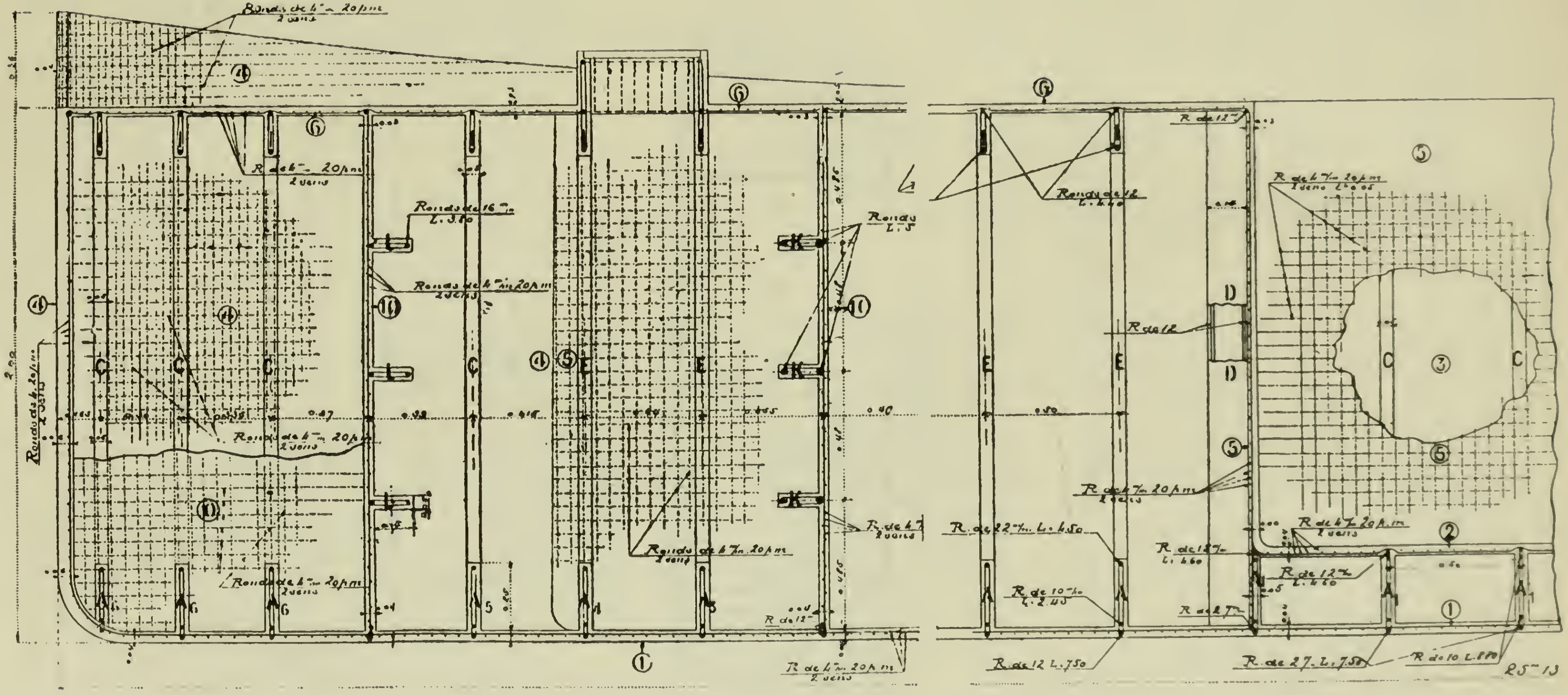


Fig. 112. Part Section of 68 cu. yd. Concrete Barge at Bahia.

In the arrangement patented by N. K. Fougner in 1913 (Eng. Pat. 19,077—1913) the vessel is symmetrical about the longitudinal and transverse axes; both ends are exactly alike, with a watertight bulkhead at each.

The deck *A* (*Fig.* 118) consists of a concrete slab and beams *D* reinforced with bars or rods as shown, and is calculated as continuous over the supporting beams and reinforced accordingly—*i.e.*, near the bottom, about $\frac{1}{2}$ in. above the underside of the deck *A*, are placed rods *E* spanning between beams *D*. These rods absorb all tensile stresses caused below the neutral axis in the deck slab by the positive bending moment from cargo placed on the deck and form the main reinforcement. The rods *F* near the top surface of the deck slab *A* are placed over the supporting beams *D* and parallel to the rods *E*. Their length is approximately half that of the rods *E* and they provide for all tensile stresses caused by negative bending moments over the supporting beams from loads placed on the deck.

Transversely to the main reinforcement are placed a few light rods *G* in each panel placed approximately in the centre of the deck slab *A* or slightly nearer the top surface. These merely absorb stresses from shrinkage and changes in temperature in the concrete, and do not assist in carrying the loads; hence, they may be termed temperature rods.

The beams *D* which support the deck *A* are calculated as so-called *T* beams and have bevelled angles as shown to protect against shear stresses between flange and web of beam. The beams are reinforced near the bottom surface with heavy reinforcement *H*, which takes care of stresses from the positive bending moment, and continuity rods *I* are provided over the supports, as shown in *Fig.* 114.

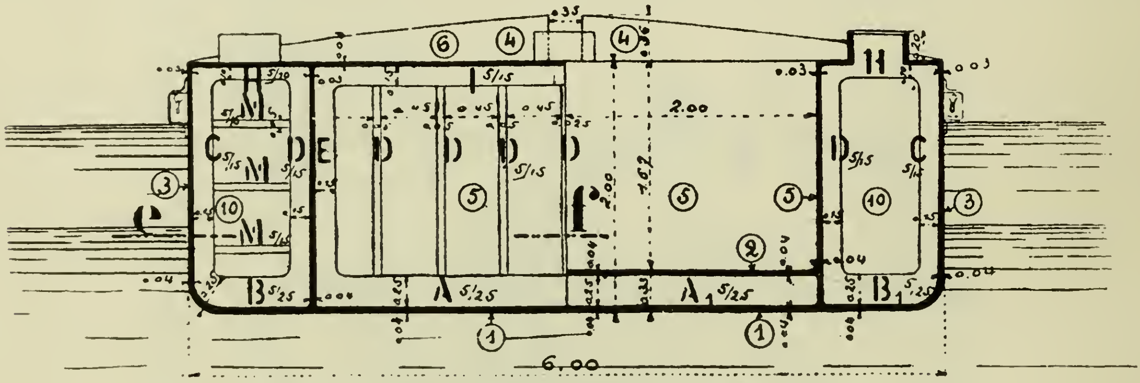


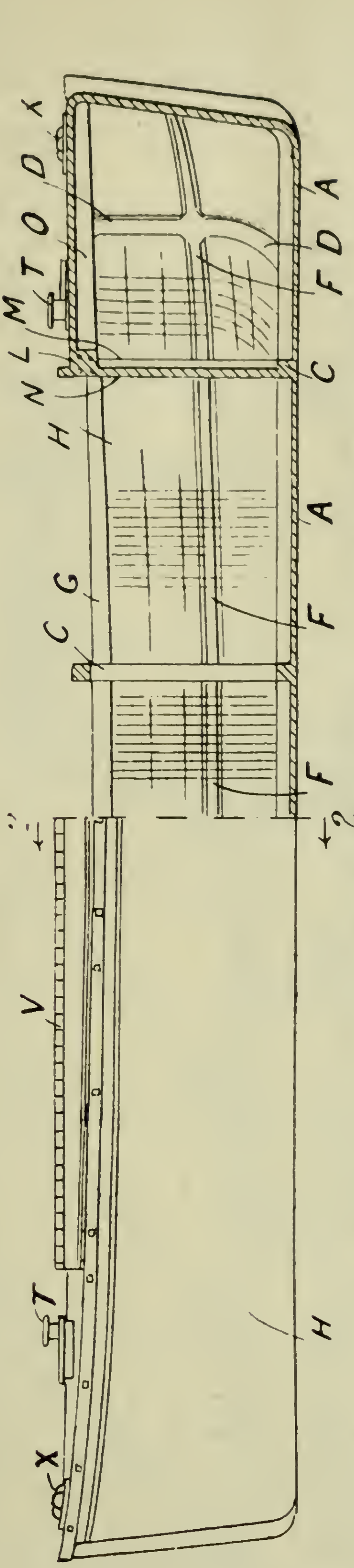
Fig. 113. Section of 68 cu. yd. Concrete Barge at Bahia.

Sometimes the rods *H* are bent up over the supports at an angle of forty-five degrees and extended into the adjoining span, taking the place of the rods *I* in this span. Stirrups *J* are also provided at intervals throughout the beams to provide for shearing stresses and are spaced closer towards the ends of the beams.

The bottom of the vessel is constructed on exactly the same principles as the deck, but reversed as the water pressure acts upward, whereas the load on the deck acts downward, and the bottom beams D^1 and designed differently to resist water pressure. The main reinforcing rods E^1 are placed near the top surface, spanning between the beams D^1; while the continuity rods F^1 are located near the bottom of the slab over the beams D^1, and the temperature rods G^1 are in the centre. The beams are reinforced with main rods H^1 near the top, and stirrups J^1 as the deck beams. The continuity rods I^1 are located near the bottom surface.

The bottom is perfectly flat with no keel protruding on the outside.

The ends of the vessel consist of a slab *C*, which is reinforced the same as the bottom slab A^1 and beams D^1.



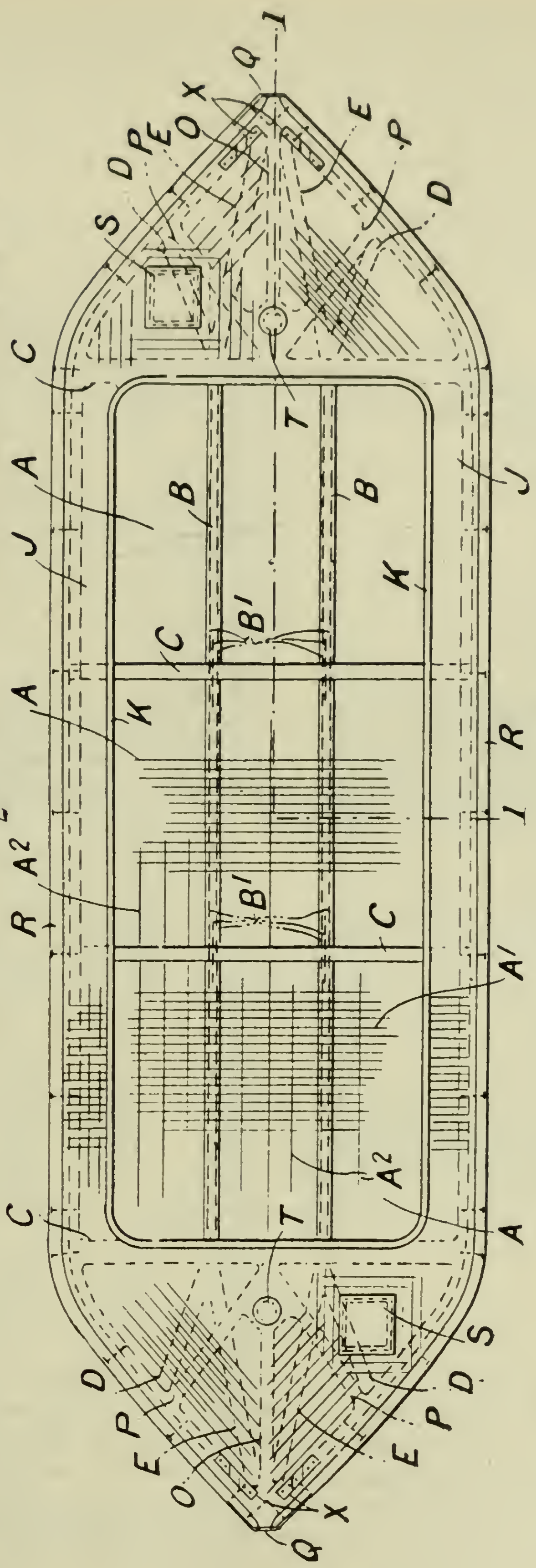


Fig. 114. Half side Elevation and half Vertical Section.
Fig. 115. Deck Plan. (Fougner's Patent.)

At the junction with the deck are beams *N*, heavily reinforced with rods near their inner surface so as to resist bending moments from shocks caused by landings or collisions, and fitted with horizontal stirrups attached to the main reinforcement.

The sides of the vessel consist of a concrete slab *O*, stiffeners *P* and beams *Q* and Q^1 at the top and bottom, as shown in *Fig.* 120.

The slab *O* is reinforced by horizontal rods *R* and R^1, by vertical rods *S* and by diagonal tension rods *T*.

The main horizontal reinforcing rods *R* are placed near the inner surface of the slab and provide for all tensional stresses caused by the positive bending moment from water pressure. The continuity rods R^1 are horizontal and parallel to *R*; they are located near the outside face of the slab, over the supporting member *P* and take the tensional stresses resulting from the negative bending moments caused by water pressure. The vertical rods *S* act primarily as temperature rods and partly assist the rods *R* in absorbing stresses from water pressure, bearing on the beams *Q* and Q^1; they are placed near the inside face. The diagonal rods *T* are subject to direct tension and are symmetrical about the vertical member P^1 in centre of truss and are thoroughly anchored at the top and bottom of the members *P* by being hooked and extended into the chords *Q* and Q^1. The stiffeners *P* are reinforced vertically near the corners with four or more rods, which are tied together with wire ties at certain intervals

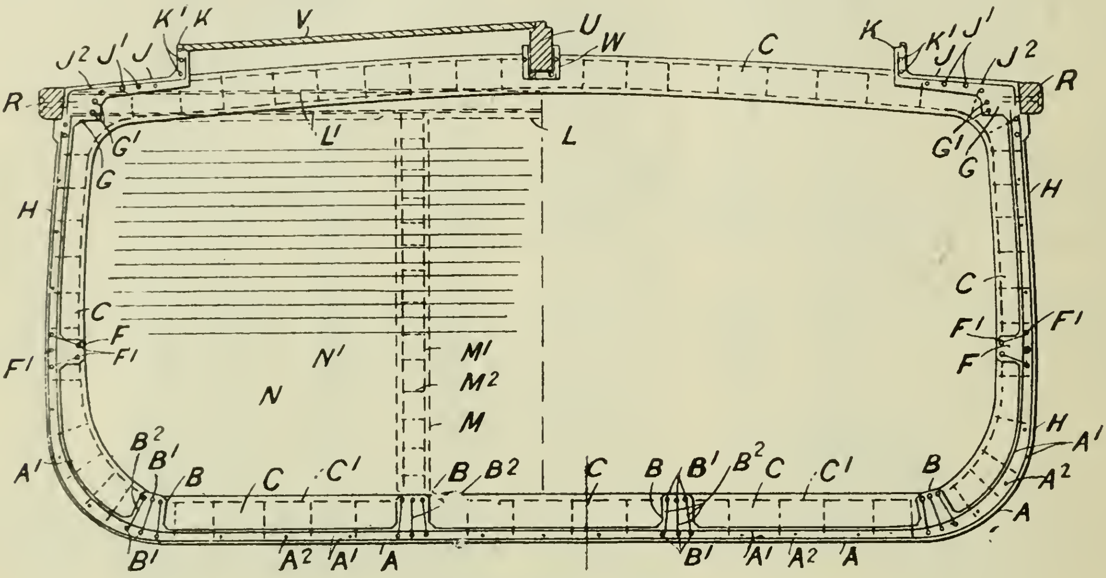


Fig. 116. Cross Section.

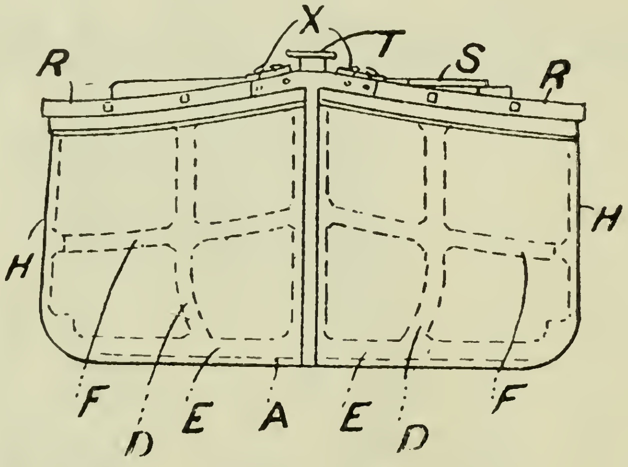
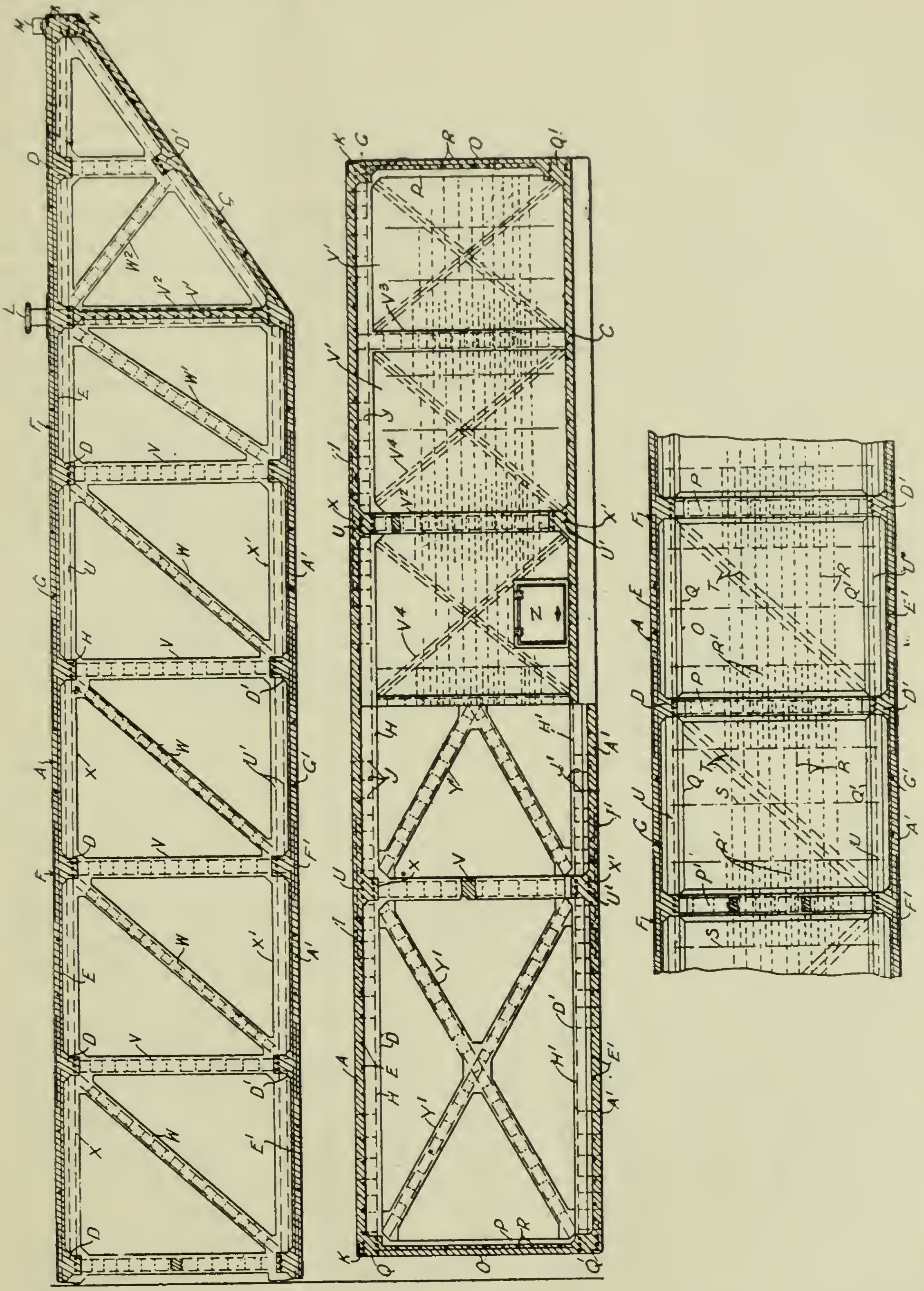


Fig. 117. Deck Plan. (Fougner's Patent.)

as shown. The chords Q and Q^1 are heavily reinforced by a number of rods U extending through the length of the sides and placed both near the top and lower surfaces of the beams. Thus the sides are really masked trusses, and as such add greatly to the strength and rigidity of the vessel.



Figs. 118—120. Fougner's Arrangement.

Two longitudinal trusses are shown in detail in *Fig.* 118, but the number may vary according to the size of the vessel. These trusses consist of columns V supporting the beams *D*, diagonals *W* and upper and lower chords *X* and X^1. The diagonals *W* are subject to tension only, but have sufficient rigidity to also resist a certain amount of compression. Both *V* and *W* are reinforced with at least four rods each, placed near the corners, hooked around the reinforcement in the chords and tied together with wire hoops as shown. The maximum spacing of the ties should not exceed the least diameter of the member. W^1 and W^2 are of heavier dimensions and are particularly intended to strengthen the vessel in case of collision when they may be subject to both tension and compression. The chords *X*, X^1 are heavily reinforced with rods U^1 running through the full length of the vessel. The lower chord X^1 is considerably reinforced more than the upper chord *X*. The latter is subject to compression and is designed as a T beam, monolithic, with the deck *A*.

In order to stiffen the vessel transversely, open trusses *Y* and bulkheads V^1 are provided as shown in *Fig.* 122. The numbers of these may vary according to the size of the vessel. *Diagonals* Y^1, placed in both directions to resist both compression and tension, are reinforced like the diagonals *W* with longitudinal rods and wire ties. The chords are beams *D* and D^1, in which are inserted extra rods near the centre of the beam, and running clear across the full width of the vessel. The bulkheads V^1 are constructed like the sides. Between the verticals V^2 and stiffeners $\acute{P}$ is placed an additional post V^3, reinforced like the verticals *V*. In addition to this reinforcement, extra rods are inserted near the inside face of all posts in the bulkhead, in order to resist the bending moment from water pressure in case the end compartment should be filled with water. The verticals *V*, V^2 are therefore designed as beams in a vertical position besides being columns supporting the deck and bottom. The slab V^1 in the bulkhead is reinforced in exactly the same manner as the side slabs, with the addition of diagonal rods V^4. The main horizontal reinforcement is run between the posts and placed near the inside face of the slab. The horizontal continuity bars are placed over the supports and near the outside face of the slab. The temperature rods and diagonal tension rods are located in the centre of the slab. The latter are duly anchored at junction with the posts and in this manner promote the truss action in the bulkheads.

In Lehmann and Kreuzer's design (Eng. Pat. 9,459—1913) the bottom of the vessel (*Fig.* 121) is provided on the inside with a pair of keels *b* and two sets of transverse ribs, viz., a set of main ribs, such as *c* and a set of smaller intermediate ribs placed transversely to them. The main ribs may be of uniform height, or they may be higher in the centre than at the ends, as illustrated in *Fig.* 116, and may be provided with openings, to reduce the weight.

The hull is also reinforced by thin horizontal rods and also with diagonal rods arranged in groups and adapted to form diagonal bracings. Near the beam ends, the sides are strengthened by external ribs approximately horizontal and armed with convex steel plates.

In Fig. 122 the vertical lines represent the thick rods in the side ribs, the horizontal lines the thin rods in the skin which at the top and bottom are placed close together to form a horizontal bracing. Diagonal bracings are also formed by groups of parallel thin rods, as shown in *Figs.* 122, 123 *and* 124. As shown in *Fig.* 121, the upper ends of the main ribs *c* are joined together with side brackets c^1 forming part of the deck.

Details of the barges built by the Lord Construction Co., of New York, and the Taylor Engineering Co., Ltd., of Vancouver, are shown in *Figs.* 125 and 126.

One of the most careful attempts to ascertain the best design for concrete barges is that made by the Joint Committee of the American Concrete Institution and the Portland Cement Association. The arrangement they recommend is illustrated in *Figs.* 127–129.

The midship section is rectangular with the exception of a slight crowning of the deck and a slightly upward inclination of the bottom toward the bilges. The hull is divided into five compartments by four transverse bulkheads, the three centre compartments are served by three hatches, each 14 ft. by 19 ft. The stress in the concrete in extreme fibre is limited to 1,000 lb. per sq. in.

For a ship of the same size, Lloyd's rules require that the ribs or frame be placed 24 in. on centres. This was deemed too close for economical use of concrete, and a spacing of 4 ft. was adopted, making the resisting moment of each frame at all points equivalent to twice the resisting moment of one frame in the steel ship. In determining the strength of the frames of the steel ship as fixed in Lloyd's rules no allowance was made for the effect of the tank top (floor of the hold) or of the bottom plating. Assuming a spacing of frames of 4 ft. and a resisting moment equivalent to two frames, under Lloyd's rules the floor plate or transverse girder supporting the ship's bottom was found to require a concrete girder 36 in. deep and 10 in. wide, including the bottom slab.

To provide for the negative and positive bending moment in the shell, two lines of reinforcement were assumed—one near the outer surface and one near the inner surface. The load being uniform, the positive bending moment at the centre between frames will be approximately one-half of the negative bending moment at the frames.

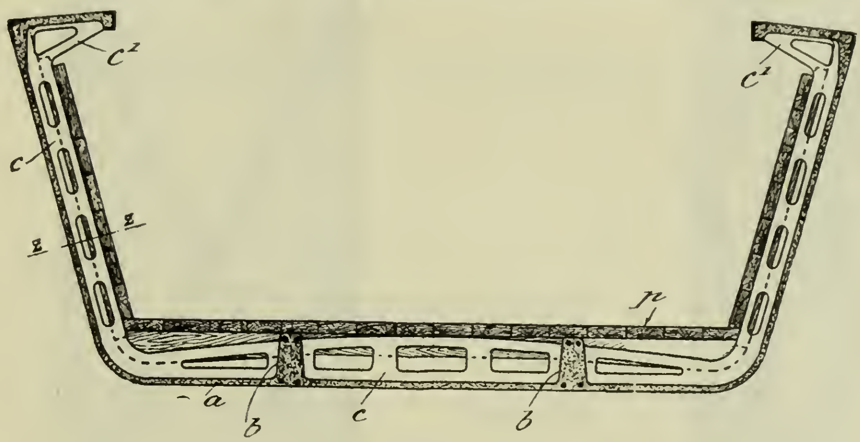


Fig. 121.

Two-thirds of the total amount of steel was therefore provided near the outer surface and one-third near the inner surface, all the bars being straight, it being considered impractical to bend the bars. From the lower turn of the bilge up to the deck one size of bar was assumed, with variable spacing to meet the required strength at different depths. The thickness of the shell from the upper turn of the bilge to the rail was fixed at 4 in. To provide adequate strength against " hogging " or " sagging " tension steel to the extent of 140 sq. in. was provided in both deck and bottom. This steel was considered also as providing reinforcement for local stresses in the bottom due to hydrostatic pressure and in the deck due to load. It was placed in two layers to take up both negative and positive moments, two-thirds being near the outside surface and one-third near the inner surface. Since this steel will be subject to compression as well as tension, the two layers were securely tied together to prevent buckling. To provide adequate protection to the steel, and also to provide sufficient area in concrete to take up the compression stresses, the thickness of the bottom up to the upper turn of the bilge was made 5 in. The deck between the bulwark and the line of the hatch coamings was made 5 in. also. The deck between hatches and within the lines of the hatch coamings was made 3 in. thick. The deck itself not being sufficient to provide sufficient area in concrete, additional area was added at the junction of the deck and the sides, where it

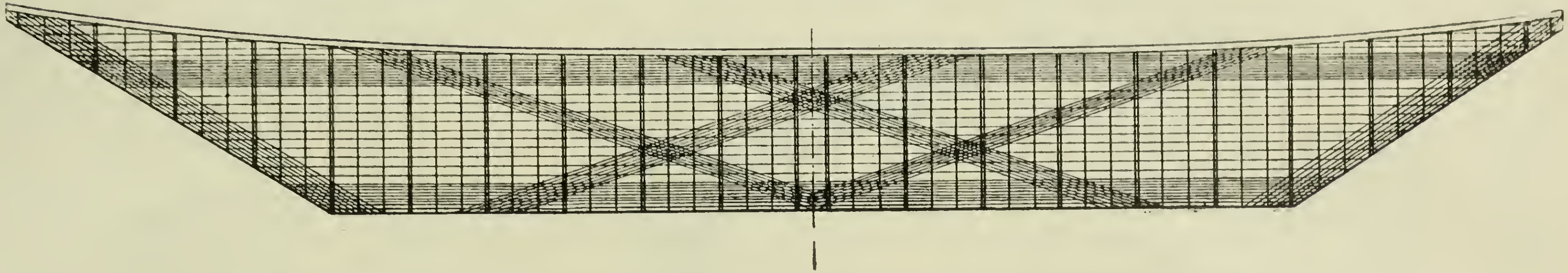


Fig. 122.

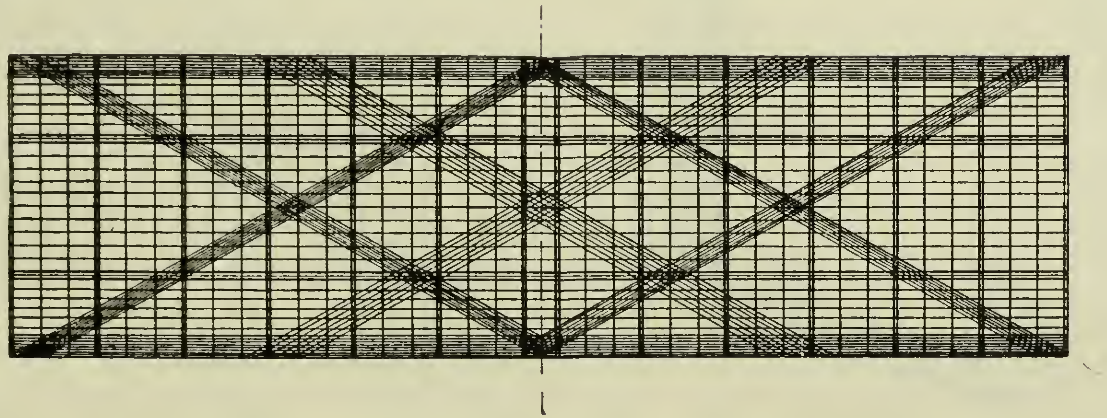


Fig. 123.

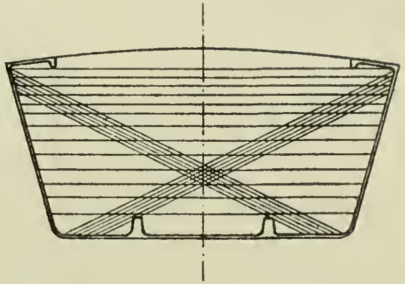


Fig. 124.

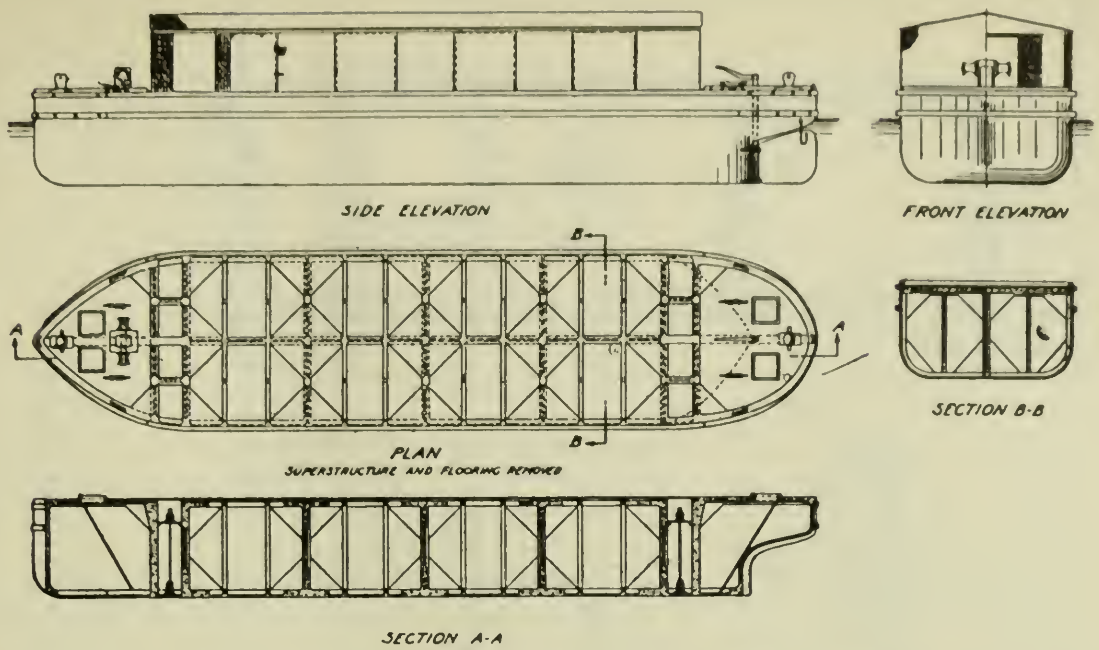


Fig. 125. Design for Concrete Barge particularly suitable for Dock Loading, with capacity from 250—300 tons, designed by the Lord Construction Co.

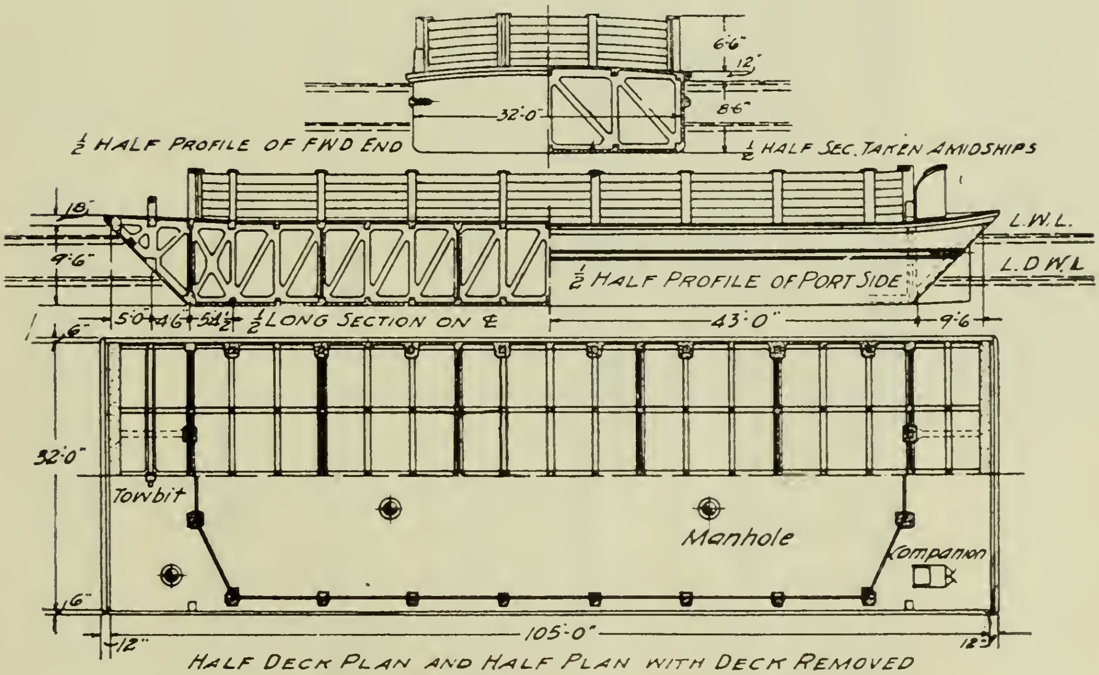

6'6"
12"
32'-0"
8'6"
½ HALF PROFILE OF FWD END
½ HALF SEC. TAKEN AMIDSHIPS
18"
9'6"
L.W.L.
L.D.W.L
½ HALF PROFILE OF PORT SIDE
5'0"
4'6"
5'4½"
½ LONG SECTION ON ℄
43'0"
9'6"
6"
32'0"
Towbit
Manhole
Companion
6"
105'-0"
12"
12"
HALF DECK PLAN AND HALF PLAN WITH DECK REMOVED

Fig. 126. General arrangement of a 500 ton d.w. Concrete Scow designed by the Lord Construction Co

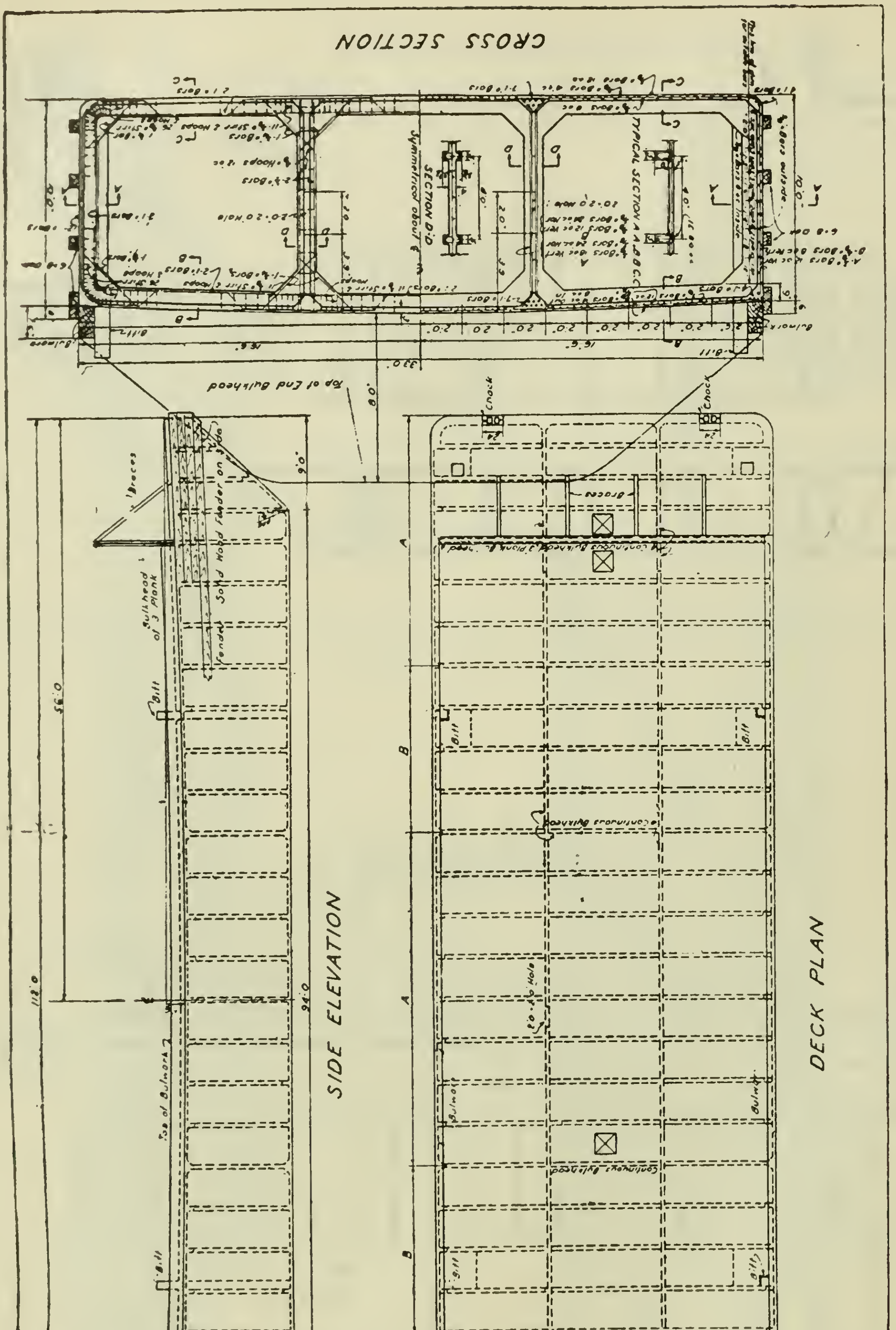


Fig. 127. Design for Concrete Deck Barge. 465 tons d.w., at 8 ft. 6 in. draft, prepared by R. W. Boyd for the Joint Committee on Concrete Ships and Barges of the American Concrete Institute and Portland Cement Association.

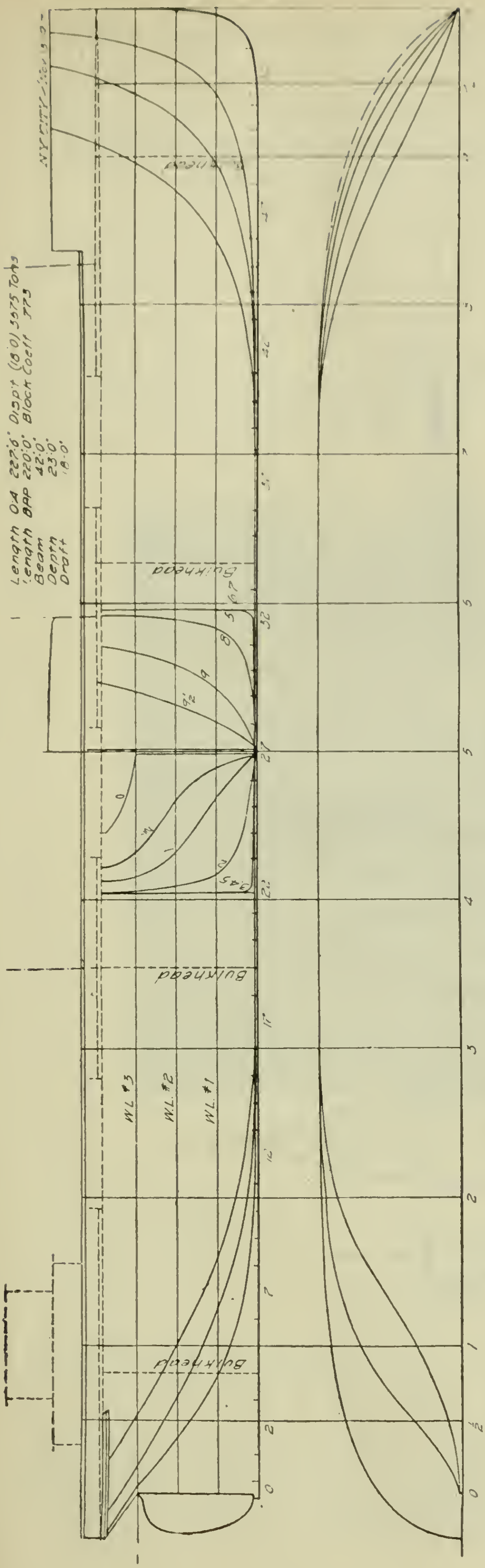

Length OA 227'6" Displ't (18'0) 5575 Tons
Length BPP 220'0" Block Coeff .775
Beam 42'0"
Depth 23'0"
Draft 18'0"
Bulkhead
WL #1
WL #2
WL #3
N.Y. CITY

Fig. 128.

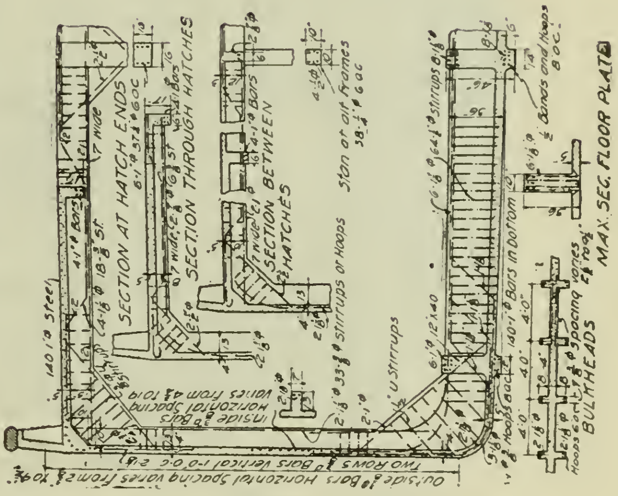


Fig. 129

would also tend to increase the resistance to horizontal shear, which would be high at that point.

In the bottom, three longitudinal members running from bow to stern were provided, one on the centre line and one at each lower turn on the bilge. These longitudinals or, "keelsons," give longitudinal stiffness, assist in distributing the load due to dry-docking and provide additional area for hogging and sagging stresses.

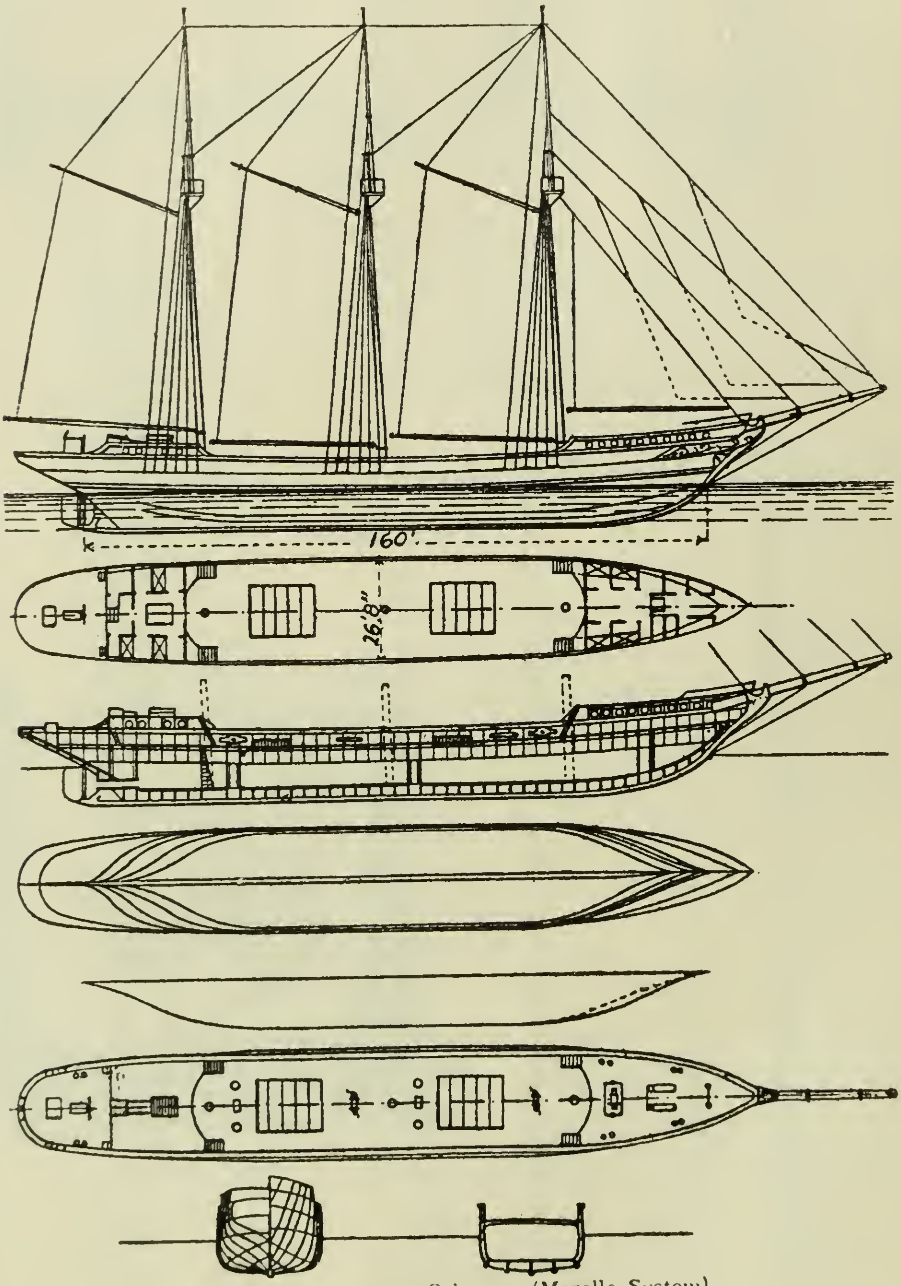


Fig. 130. Concrete Schooner (Marelle System).

The vertical frames in the sides were made 7 in. wide and 17 in. deep, including the shell, and an equivalent in strength to steel frames under Lloyd's rules. At the junction between the floor plate and the side frames a heavy gusset is provided to give additional strength at that point. A similar gusset is provided between the side ribs and the deck beam. This gusset is increased in size at the beams at hatch ends. The deck along the centre line is supported by means of posts at the ends of each hatch and at alternate deck beams between hatches.

The bulkheads consist of 4-in. slab reinforced near both surfaces and stiffened by reinforced ribs 20 in. in depth over all and 7 in. wide, spaced 4 ft. on centres.

SELF-PROPELLED BARGES, CARGO BOATS, ETC.

The designs for the larger barges illustrated in the foregoing pages are usually suitable for self-propelled vessels, but it is convenient to consider the latter separately.

The motor cruiser *Wanderer* (p. 14) is built with a framing of angle steel, with an **H**-beam keel, the framing being covered with galvanised expanded metal, the latter being plastered with concrete.

The schooner illustrated in *Fig.* 130 is built on a different principle to the preceding vessels. According to M. R. Marelle, a naval engineer of Marseilles, the ordinary methods of calculation and design of reinforced concrete structures are not applicable to seafaring vessels, and it is necessary to take more closely into account the enormous flexional and torsional stresses which are often applied quite suddenly and in rapid alternations to ships at sea. He declares that the strength of the concrete ought not to enter into any calculation, but that the reinforcement should be strong enough of itself to resist any force to which the vessel is likely to be exposed, this strength being secured by fixing the cross pieces of the reinforcement firmly by screwing, soldering or any other suitable mechanical means. He prefers to use a few reinforcing members of large diameter rather than a large number of smaller pieces. Marelle considers that the weight of the reinforcement should be one-quarter of that of a hull built completely of metal.

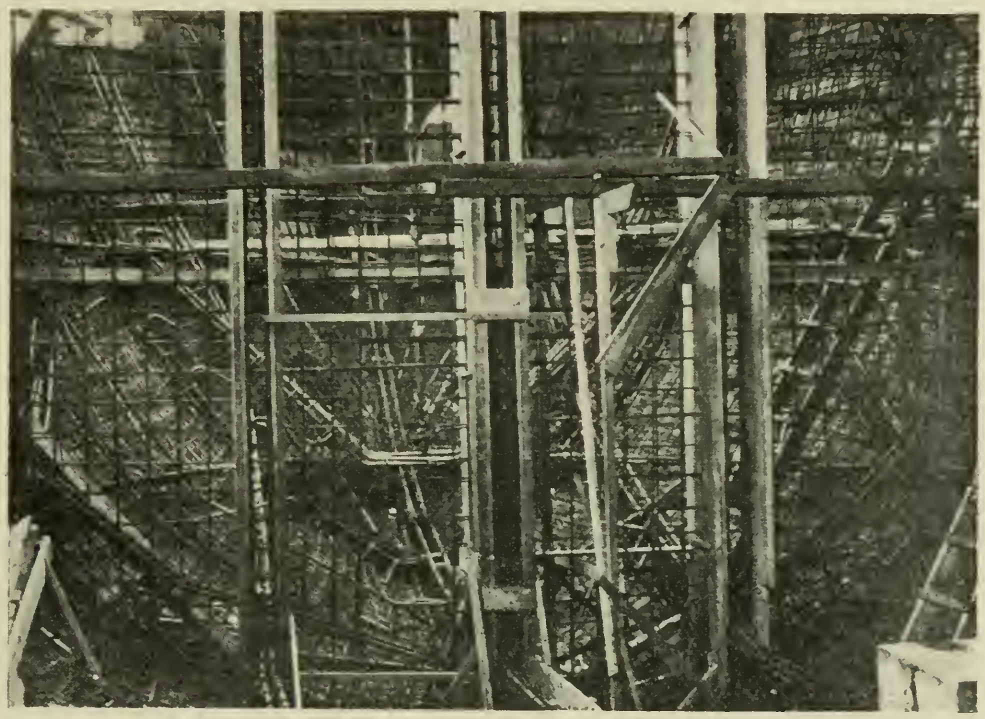


Fig. 131. Showing the Completed Steel Reinforcement near the bows.
The First Reinforced Concrete Sea-going Vessel built in Great Britain.

Fig. 130 shows a motor-driven and sailing schooner of 600 tons displacement when loaded which is capable of "doubling the Cape of Good Hope." This vessel has a double keel rising at each end to the water-line. The water-tight compartments are double. The decks are of reinforced concrete. The weight of the vessel when ready to receive its cargo is 300 tons; the free-space in the three holds is about 2,700 cu. ft.

At first sight it would appear as though this mode of construction would lose three great advantages which it is usually sought to obtain from the use of reinforced concrete—viz., rapidity, cheapness of construction and the use of a minimum of steel. M. Marelle has stated, however, that the time required for building such a vessel as the one illustrated is less than six weeks, and undertakes to put on the stocks every three weeks a vessel of any size up to 2,000 tons, the cost of the hull not to exceed half that of a vessel of similar shape and size constructed wholly of steel.

There is a further objection to making the concrete merely a cover for the steel—namely, the greatly increased weight of the vessel. British and American designers are apparently agreed that the use of so much steel as M. Marelle stipulates is unnecessary and undesirable, and that it ignores a fundamental principle in reinforced concrete construction that the reinforcement must be placed near the surface of the concrete, both inside and outside, so as to resist tension due to bending moment in either direction. Steel netting in the neutral plane of a concrete sheet is useless as tension reinforcement. Even the proposal to retain the main steel framing is unsound and uneconomical. Structural steel is always unsuitable as reinforcement, being more expensive and less effective than ordinary rods and stirrups.

The first seagoing concrete vessel built in Great Britain was built with curved lines like those of a steel vessel, notwithstanding the extra cost involved. The hull is divided into five holds by four watertight bulkheads, three of the compartments being used for cargo, one (forward) for stores and chain locks and one (after) for the crew's quarters. The reinforcement near the bows is illustrated in *Fig.* 131.

In the construction of this barge 65 tons of steel and 260 cu. yd. of concrete were used

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MEMORANDA.

Side Launching a Concrete Lighter.—Concrete lighters, 112 ft. long, 11½ ft. deep, and of 34 ft. beam, weighing about 500 tons, have been launched sideways at the yard of the Aberthaw Construction Co., at Providence, R.I.

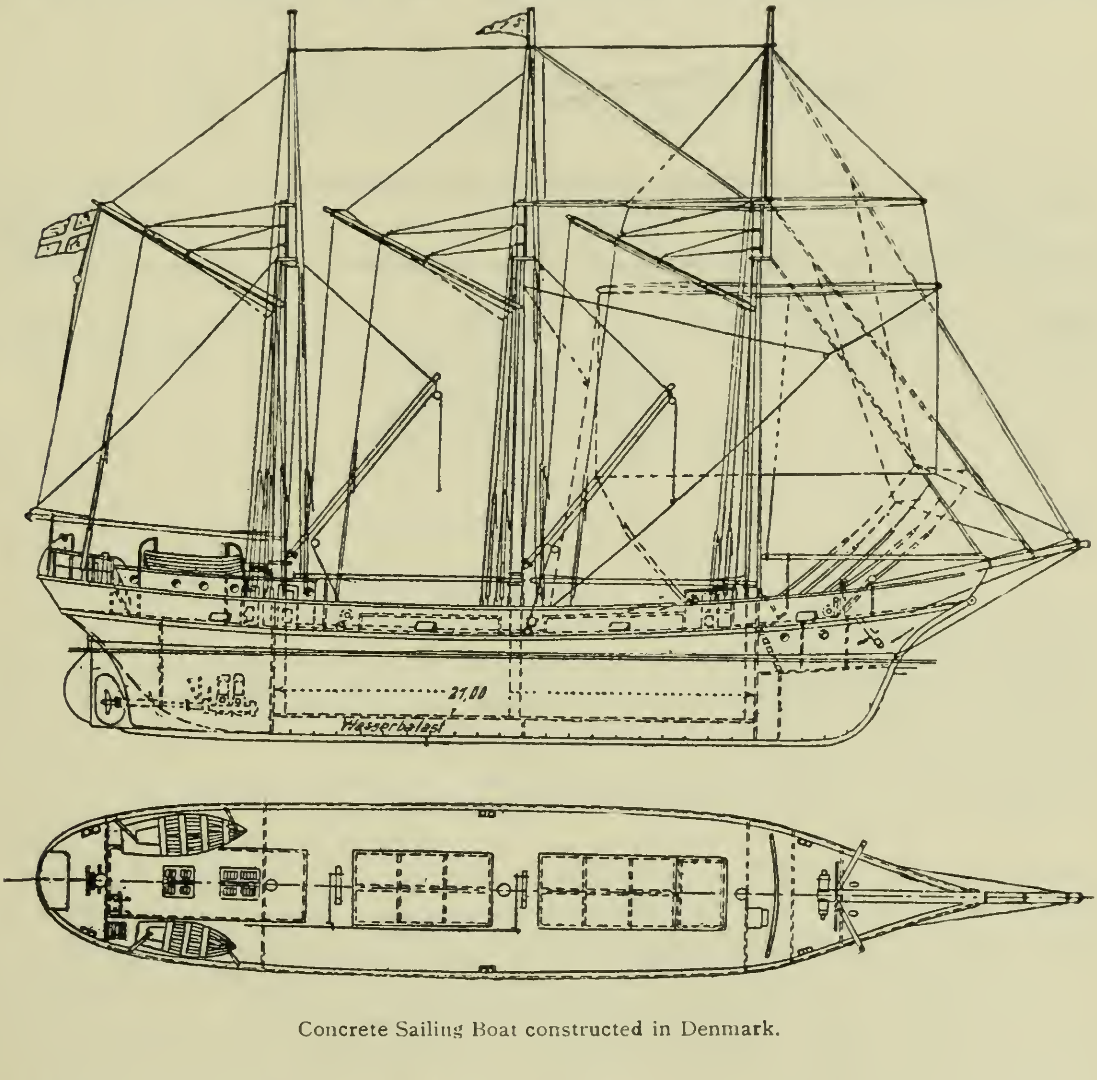
Four pairs of launching ways were placed under each lighter, the ways being built at mean high-water level, with the outer ends just awash at high tide, and the area immediately in front of the ways, 100 by 130 ft., was dredged out to a depth of 4 ft. The ways are set at an incline of 1½ in. in 12 in. and are built of 12 by 12-in. yellow pine, dressed smooth on the top and resting on sills laid in trenches, the outer end being supported on piling. Each pair of ways is 9 ft. wide, outside measurement, and the pairs are set at an interval of 24 ft. between centres. Across each pair of ways, under each longitudinal bulkhead and in the centre of each watertight compartment, was placed a yellow-pine slider, which carried the wedges and blocking.

The outer unit of each pair of ways at either end of the lighter constituted the trigger way, being extended to the rear and capped with a piece of yellow pine to afford a bearing surface for the base of jacks which served to start the vessel on the ways. The trigger ways were reinforced by two 1-in. round steel bars fitted with turnbuckles and running back to deadmen which also served to anchor the block and tackle which formed part of the releasing gear.

Under the lighter at either end was placed a cradle of 10 by 10 in. yellow pine, fitted with an eye at one end and at the other a lip which set against the side of the barge, the shoe being held snugly against the bottom of the lighter by a ½-in. wire rope running up to the deck. On the under side of the shoe is a recess to take a strut running down to the trigger bar, which was a piece of 10 by 10 in. oak; the outer end of this was fastened to a deadman by a manila rope 6 in. in circumference, doubled and made taut by means of a block and tackle attached to the deadman in the rear of the launching way. The block is connected to the 6 in. cable by a double strand of 4 in. manila rope passing over the cutting block. From the outer side of the trigger a dog shore, 8 by 8 in., butted against the piling on the outer end of the launching way. Directly under the side of the barge was placed a tumbling block, bevelled at either end ; this fell clear when the lighter started down the ways.

When the concreting had been completed the barge was jacked up on building movers' jacks, carried on railroad ties on either side of each launching way, and the formwork was removed. The barge then was lowered to the blocking on the sliding ways. From this point the barge was kept in place on the ways by the cradle, the strain being taken by the manila cables attached to the trigger bars.

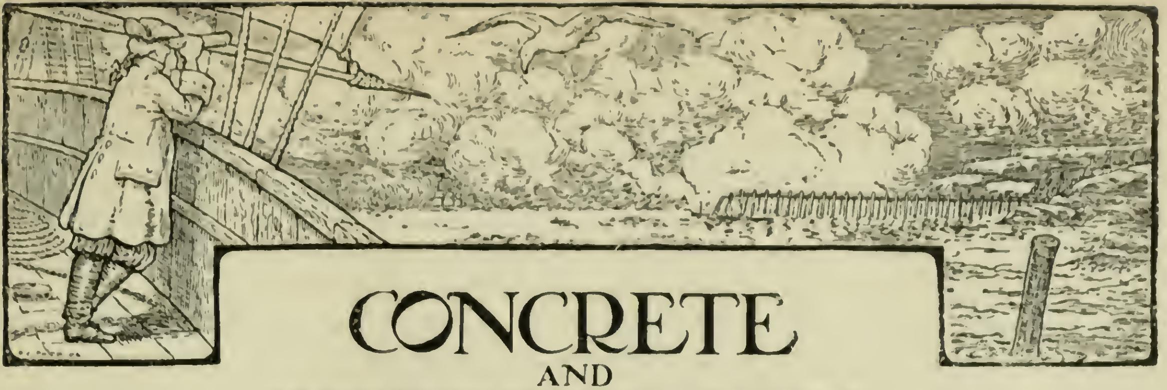
A few turns on the jacks served to loosen the ship on the sliding ways, and, the signal being given, the releasing gear was severed simultaneously at the two cutting blocks. The resistance of the vessel striking the water broadside was sufficient to arrest the momentum, no rope stops being necessary.



Concrete Sailing Boat constructed in Denmark.

Two Concrete Sailing Boats.—With one or two exceptions, all the vessels hitherto constructed of concrete have been barges or self-propelled vessels. Recently, however, two concrete sailing boats of 325 tons have been launched at Naestved, in Denmark. These vessels conform to the regulations of the Danish Government and to Lloyd's Register. These vessels ride about 2 ft. deeper in the water than those of the same dimensions, but made of steel, but they are no heavier than the corresponding vessels made of wood. They are reported to be steadier in the water than wooden or steel vessels. These boats are fitted with a motor of 80 h.p., which enables the empty vessel to travel at 6 knots.—(*Beton u. Eisen*).

A Light Reinforcement for Concrete Ships.—In order to secure greater lightness than is possible with steel reinforcement, K. W. B. Platow (Ger. Pat. 295,818) has patented the use of bamboo canes held in position by wires or other ties. The use of non-metallic reinforcement offers considerable possibilities in localities where steel is not easily obtained, though the latter is obviously preferable in most cases.



CONCRETE
AND
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"CONCRETE SHIPBUILDING"

A Monthly Supplement

Issued Free to Subscribers JUNE, 1919 *Single Copies 1/-*

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER IV (*continued*).

DESIGNING CONCRETE VESSELS.

In marked contrast to the vessel just mentioned is that designed by Messrs. James Pollock & Sons, London, and illustrated in *Fig.* 132. In this motor transport all curves are avoided except at the corners, which are rounded; the reinforcement is practically straight throughout and the form work is simplified as much as possible. For vessels sailing at a rate not exceeding nine knots, the straight lined hull causes very little additional resistance to movement provided the centre of buoyancy is placed slightly forward of amidships.

The stern frame requires special consideration and design to ensure proper attachment to the reinforced concrete work, especially where a stern tube is fitted. *Fig.* 133 illustrates Pollock's patent stern frame, the construction in several pieces being really a war measure and designed to reduce the amount of forged work to a minimum. The reinforced rods are well connected to the plates and angles.

A method that may be adopted for attaching fenders or fender angles, bollards and holding-down bolts is to cast in the concrete a tube with a flattened end that is screwed internally to take an ordinary or a cheese-headed bolt, although many fittings, such as stanchion sockets, small bollards, mooring pipes, hatch cleats, can be constructed with bulb or sprayed ends so that they can be cast in position, and consequently bolts or other attachments dispensed with. If this method is adopted, malleable cast or wrought-iron fittings should be used when possible.

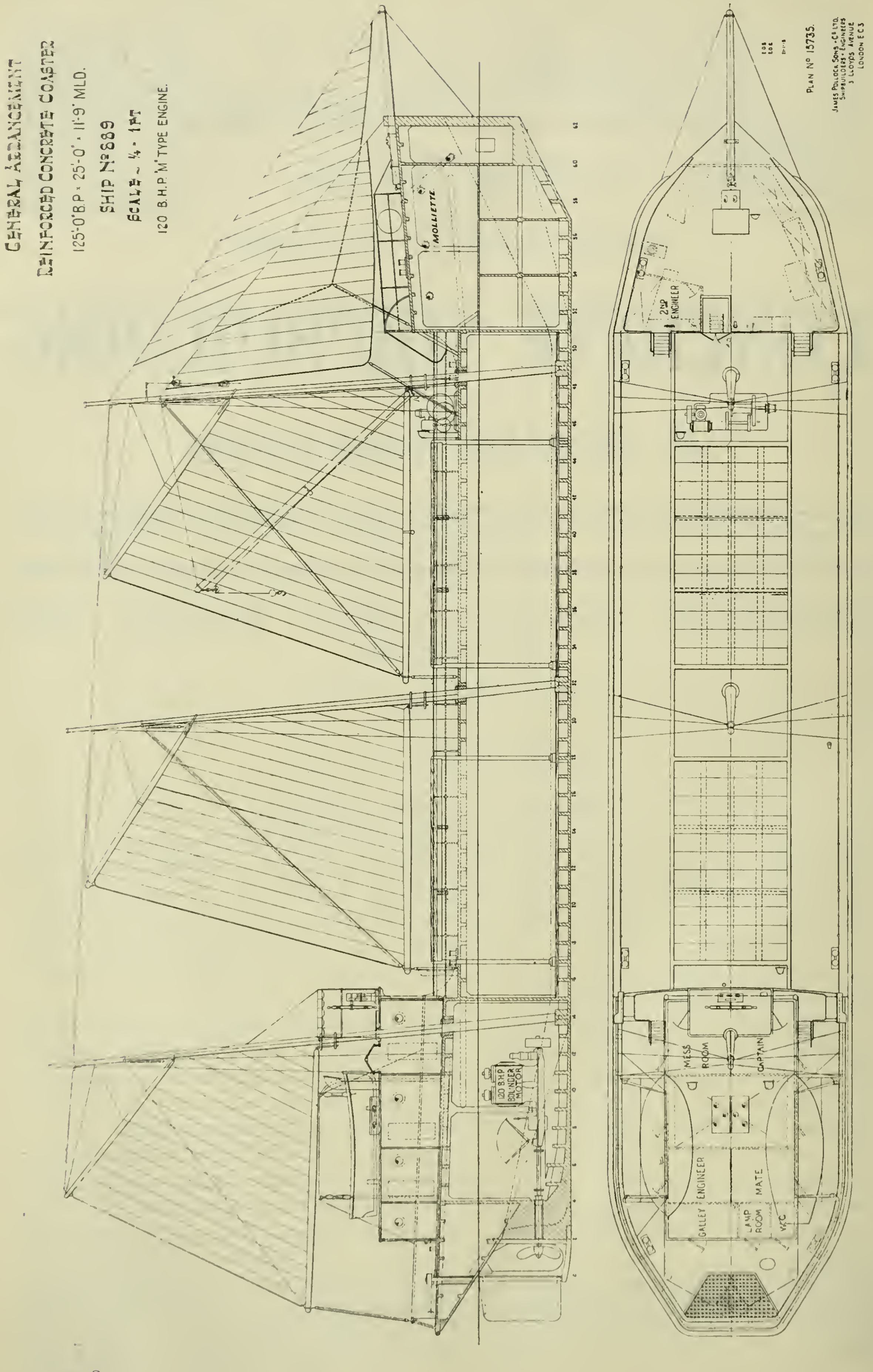


Fig. 132. Pollock's Design. Type R.W.

Bulkhead connections, hawser and mooring pipes, wash port doors, scuppers and deck pumps are placed in position before the casting of the concrete takes place, and therefore cost practically nothing to fit. Shroud plates can be held down by bolts, although plates immersed in concrete and attached to the reinforced bars would no doubt be better.

It is necessary to have a covering of concrete at least 1½ in. thick over all the bars, floors, frames and keelsons, and even where heavy bars are used it is advisable to have a covering of not less than 1 in. of concrete, and even 1¼ in. may be necessary.

The deck may have a granite finish composed of ¼ in. washed granite and cement gauged 2½ to 1, laid at the same time as the under concrete and sprinkled with fine carborundum before the casting is finished. The latest vessels being constructed by Messrs. Pollock & Sons, Ltd., have a chequer pattern cast in the finishing coat.

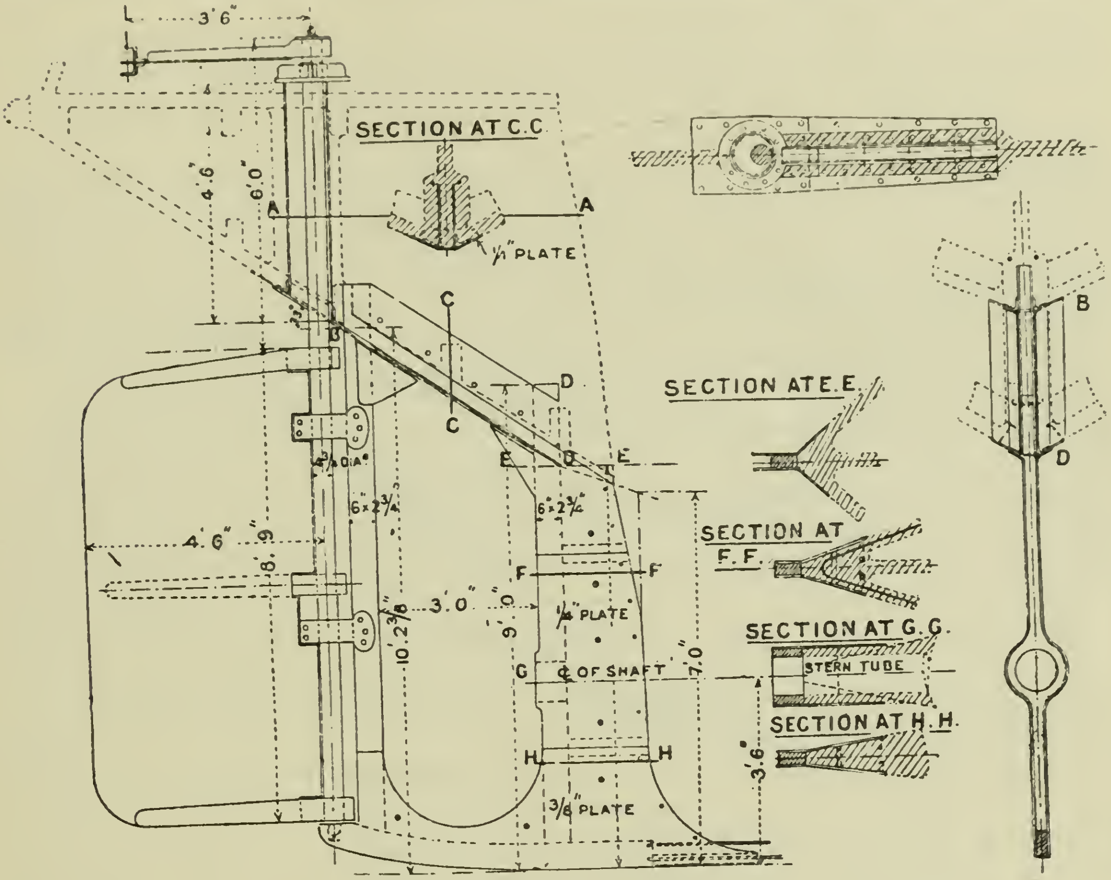


Fig. 133. Pollock s Patent Stern Frame.

It will be noticed that *Fig.* 133 shows a fillet of reinforced concrete under the wooden fender ; this fillet could be arranged locally, say 10 ft. apart, or continuously all round the vessel in way of the fender, which would enable the construction of an external side stringer to be formed, the inside stringer being consequently reduced. The advantage of the fillet is that the stress on the concrete due to the heavy falling of the ship and fender on to a pile, dolphin or dock wall is avoided.

The section and longitudinal elevation of the 500-ton auxiliary coaster introduce several new features. The vessel, having a length between perpendiculars of 155 ft., breadth 29 ft. 6 in. and a depth moulded of 13 ft. 3 in., is designed on the longitudinal principle, the frames being spaced 8 ft. apart. The hold ceiling would be fitted transversely in a vessel of this type, the frames and keelsons being hollowed to reduce weight and the inside curvature of the shell slabs or panels facilitating the use of light steel shuttering which is easily and quickly removed.

Another method of reducing the weight is shown in *Fig.* 134.

In a vessel designed in 1916 by T. G. Owens Thurston the various arrangement drawings were prepared and scantlings arranged in accordance with Lloyd's Rules for Steel Ships. Using these scantlings, a list was made up of the calculated section moduli of the various members. Upon these particulars, the engineers prepared constructional sections, on the Hennebique principle of "equivalent strength," which were adopted as a basis for calculations of weights, etc.

The design was then carefully reconsidered and calculations made as far as possible for the stresses which the vessel would be subjected to, both longitudinally and transversely, under all reasonable conditions of construction, launching and service.

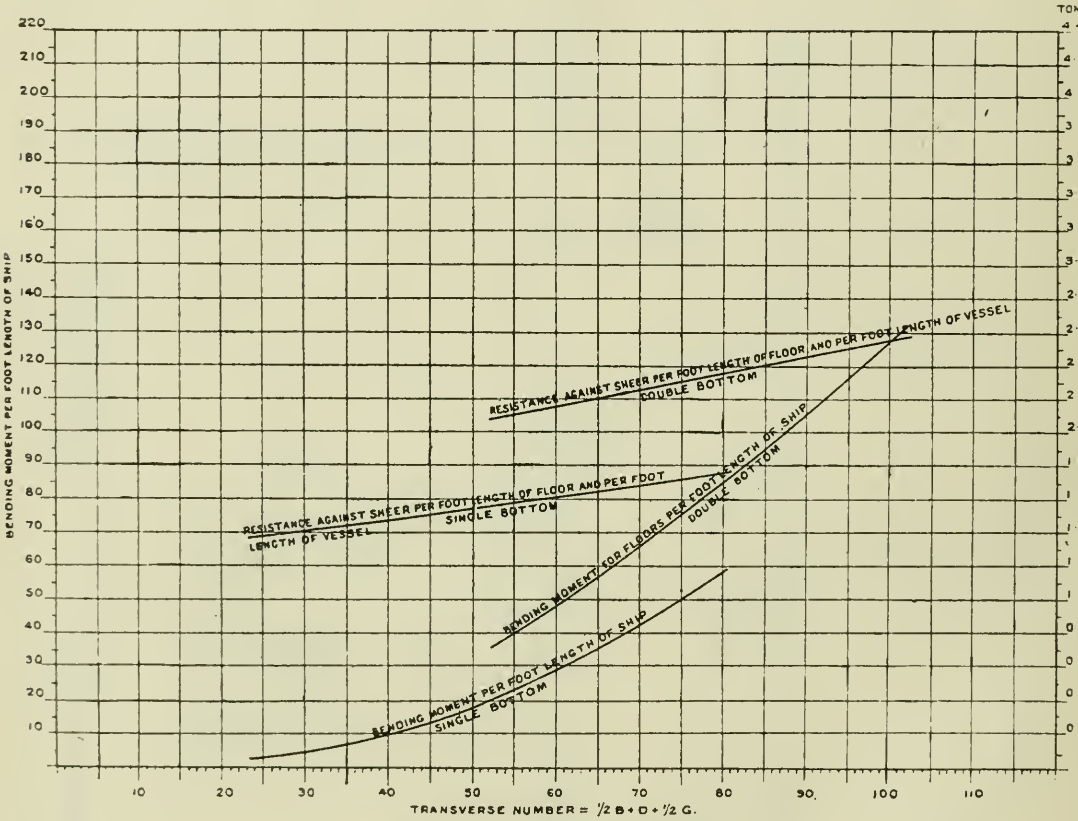


Fig. 134. Bending Moment for Floors.

One of the first things observed in the case of the reinforced concrete hull was that the centre of gravity of the structural material worked out much lower than in the case of a steel hull, the result being a greater metacentric height than was desirable. To minimise this the original beam of 34 ft. was reduced to 32 ft., and in order to obtain the same hold capacity the depth was increased from the original 17 ft. 6 in. to 19 ft. 6 in.; fortunately, from the point of view of longitudinal strength, a modification in the right direction.

In calculating longitudinal stresses, the vessel was first of all assumed to be in still water with the hold loaded uniformly to the full load condition, giving a displacement of 2,350 tons. In this condition the maximum bending moment worked out at about 4,100 tons. For hogging stresses the vessel was taken as being in the same load condition and on the crest of a trochoidal wave of length equal to the length between perpendiculars of the vessel and the height equal to $\frac{\text{Length}}{20}$, giving a maximum shearing force of 180 tons and a maximum bending moment of 10,000 ft.-tons.

In the sagging condition the vessel was assumed to be much more severely loaded, three-fifths of the cargo being placed in the middle of the hold space and one-fifth at each end respectively, resulting in a maximum shearing force of 180 tons and a maximum bending moment of 7,000 ft.-tons.

In the case of launching, the maximum shearing force reached as high as 220 tons, with a maximum bending moment of 10,000 ft.-tons. A generous margin was allowed over these figures, and the vessel was designed to stand the stresses corresponding to the following :—

Hogging moment .. .. .. $\frac{\text{Displacement}\times\text{length}}{35}=13{,}500$ ft.-tons.
Sagging moment .. .. .. $\frac{\text{Displacement}\times\text{length}}{48}=10{,}000$ ft.-tons.
Shearing force .. .. .. $\frac{\text{Displacement}}{9\cdot8}=240$ tons.

the structural material being arranged so that the tensile stress on the reinforcement, taking account of all local stresses, never exceeded 9 tons per sq. in. and the maximum compressive stress on the concrete 750 lb. per sq. in.

In calculating transverse strength the transverse framing was analysed in order to ascertain the maximum bending moment to be resisted by the floors, frames, and beams under the various systems of loading to be met with in service.

The conditions assumed, for which calculations were made, are as follows :—

(1) Vessel, without pillars, loaded to deep draught in still water. Cargo load in hold and on deck.

(1*a*) Vessel, with two pillars fitted, one at each side of hatch opening, loaded to deep draught in still water as in condition (1).

(2) Vessel, with two pillars fitted, loaded as in (1), and situated on wave crest, with no cargo on floor girder.

(3) Vessel, with two pillars fitted, loaded, and situated in wave hollow with full cargo, load centrally placed below hatches and no deck cargo.

(4) Vessel, with two pillars fitted, in light condition, in dry dock, docked on centre keel.

The calculations were investigated on the " principle of least work " taking the reinforced framing as monolithic.

In the moment as calculated there have been taken into account the stresses in the framing where only a partial support is received from the pillaring through the medium of longitudinal girders spanning between the transverse frames. The scantlings of the framing have been proportioned to the more severe conditions met with at the centre of floor girders, bilge, side frame, deck corner, and beam.

It may be observed that if the floor girder is designed to resist the bending moment in condition (2), it is also strong enough to meet the docking condition in condition (4), where the bending moment is about two-thirds that of condition (2). In condition (3), the bending moment is reversed in direction and the floor tends to deflect downwards, caused by a bending moment approximately two-thirds of that causing the upward deflection in condition (2).

To provide an estimate of the bending moment to be allowed for in the first instance, the framing was treated as a continuous girder, and the free bending moment calculated for the several spans. These were plotted on a straight base representing the neutral axis of the framing, and the theoretical fixing moment lines drawn. At the points of junction between the floors, frames—where the amounts of the fixing moments varied—and beams, the difference in bending moment was proportioned to the expression $\frac{I}{L}$ of the member on each side of the joint.

Neutral axis above base

$$=n=\frac{B_s.d_s^2+2m\,(A_c.d_c+A_t.d)}{2\,\{B_s.d_s+m(A_c+A_t)\}}=\frac{36\times4^2+2\times15\,(4\cdot16\times2\cdot7+3\cdot85\times33\cdot5)}{2\,\{36\times4+15(4\cdot16+3\cdot85)\}}=9\cdot1\text{ in.}$$

Moment of inertia

$$=I=\frac{B_s.n^3}{3}-\frac{B_s.X^3}{3}+m.\,A_t(d-n)^2+m\,.\,A_c(n-d_c)^2=\frac{36\times9\cdot1^3}{3}-\frac{36+5\cdot1^3}{3}+15\times4\cdot16\,(9\cdot1-2\cdot7)^2=44{,}304\text{ in.}^4$$

Frame spacing $=3$ ft.

$$I\text{ per ft. of spacing}=\frac{44{,}304}{3}=14{,}768\text{ in.}^4$$

$$I_s\text{ per ft. of spacing}=\frac{14{,}768}{15}=985\text{ in.}^4\text{ for steel reinforcement.}$$

Moment of resistance for steel $=$ M.R.S. $=\frac{I_s}{d-n}=\frac{985}{33\cdot5-9\cdot1}=40\cdot37$ in.^{3} With B.M. of 30 ton-ft., max. stress $=9$ tons per sq. in.

Moment of resistance for concrete $=$ M.R.C. $=\frac{I}{n}=\frac{14{,}768}{9\cdot1}=1{,}623$ in.^{3}

Basis for Strength Calculation.—As a basis for calculation of strength, the following were adopted as working limits for safe stresses on concrete and steel :—

CONCRETE

Item.	Working Stress, lb. per sq. in.	Ultimate Stress, lb. per sq. in.
Compression in beams	750	4,000
Compression direct	700	4,000
Shear	70	280
Adhesion	60	240
	100	500

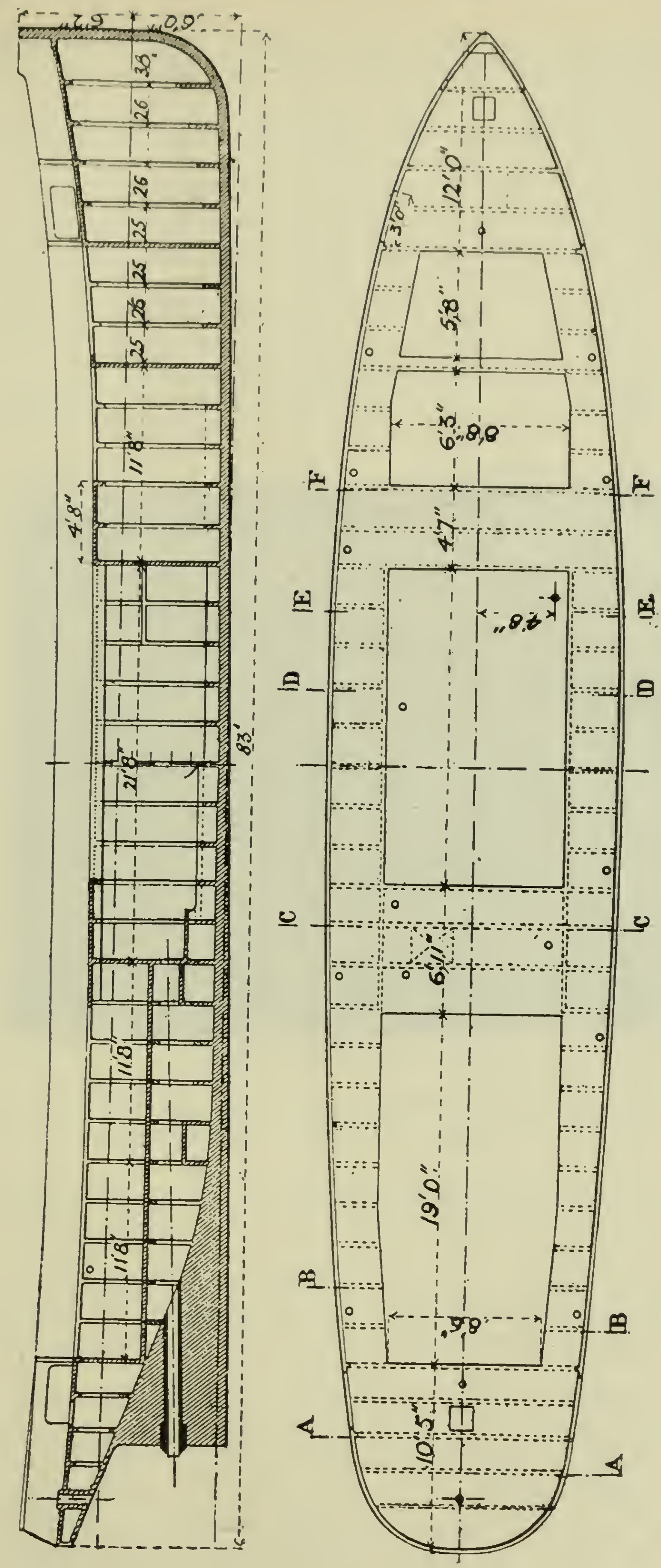
STEEL.

Item.	Working Stress.	Elastic Limit.	Ultimate Stress.
Tension, spiral bars	9 tons, sq. in.	23½ tons, sq. in.	30-36 tons
Tension, plain bars	7½ ,, ,,	15 ,, ,,	27-30 ,,
Compression	7½ ,, ,,	15 ,, ,,	27-30 ,,
Shear	5½ ,, ,,	—	24 ,,

The weight of steel in the reinforced concrete ship is about 42½ per cent. of that in the steel ship. This is not by any means such a large reduction as some writers on reinforced concrete ship construction have anticipated, nor is it the minimum quantity which would probably be adopted. Actual service will perhaps give an indication where weight may be saved, either in the steel or concrete of the hull ; and that such saving will ultimately be effected, even with identical methods of construction, may be confidently anticipated.

Mr. Thurston came to the conclusion that the most economical as well as the most efficient rod for ship construction was that known as the spiral bond bar.

When designing the vessel, a simple midship section was adopted having a perfectly straight side and bottom, with only a very small curvature at the bilge. This section was retained in a parallel middle body for half the length of the vessel amidships, and the waterlines forward rounded into an easy entrance, still retaining, however, the



Figs. 135-136. Plan and Section of a Towing Boat in France.

straight-line sections. In rounding in the waterlines aft, the straight-line sections were retained as far as possible, and then run aft to the propeller and faired in with a minimum of curvature.

To obtain a reasonably good form, trials were carried out in an experimental tank as follows : A model was made fuller than was actually required and cast thick enough locally to allow cutting off at certain parts. After the curve of resistance had been obtained with the original model the bottom part of the bow was fined with an improved result. Then the after-body was similarly fined with further advantage. A further fining of the bow and then, again, of the stern still improved the form, which was now reasonably comparable with an ordinary cargo-boat form of the same dimensions and displacement. The total modifications made were comparatively slight, amounting to 23 tons, and reducing the block coefficient by ·01.

The load waterline and curve of areas have generally been regarded as the determining features of the resistance of an ordinary form, but it was found that the influence of the knuckle was so marked that, with the waterline unaltered and practically the same curve of areas, a reduction of 40 per cent. was made in the resistance.

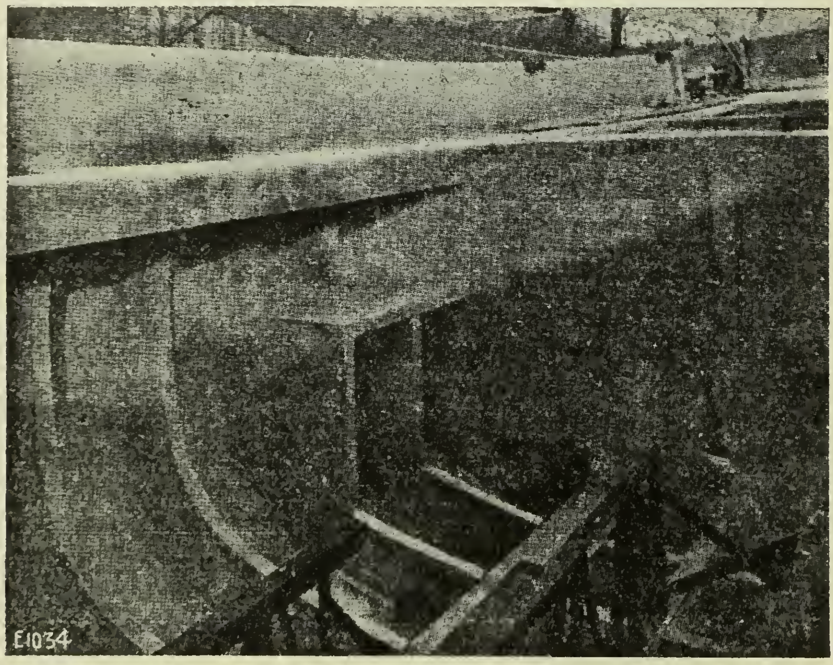


Fig. 137. Showing Ribs of Towing Boats in France.

The lines ultimately adopted may therefore very reasonably be considered as the most suitable for simplicity of shuttering and for easy construction in reinforced concrete.

The deck has a camber of 8 in. in the full breadth, but here again curvature has been avoided, the crown being on level flat 4 ft. each side of the centre line, the reinforcing deck sloping in a straight line to the side, and the deck at centre is straight fore and aft.

A number of towing boats recently built on the Seine, near Paris, by Pelnard-Considère, Caquot et Cie. (*Figs.* 136 *and* 137), are divided internally into six compartments, one for ballast and usually containing the locker for the chains, a second for stores, a third for fuel, a fourth for the engine or motor, a fifth for the crew, and the remaining compartment for ballast. The frame consists of a series of ribs, each 14 in. by $\frac{3}{4}$ in., spaced 2 ft. 2 in. apart, surmounted by a rim $2\frac{1}{2}$ in. deep, the whole

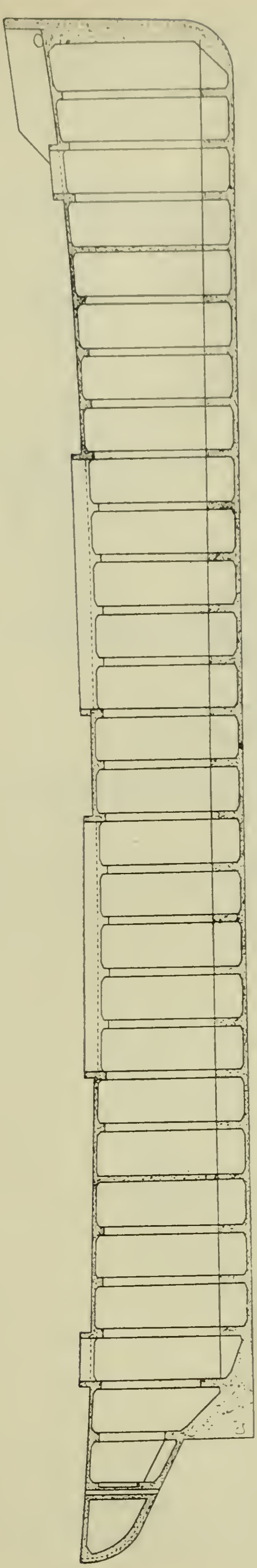


Fig. 138. Longitudinal Section of Vessel.

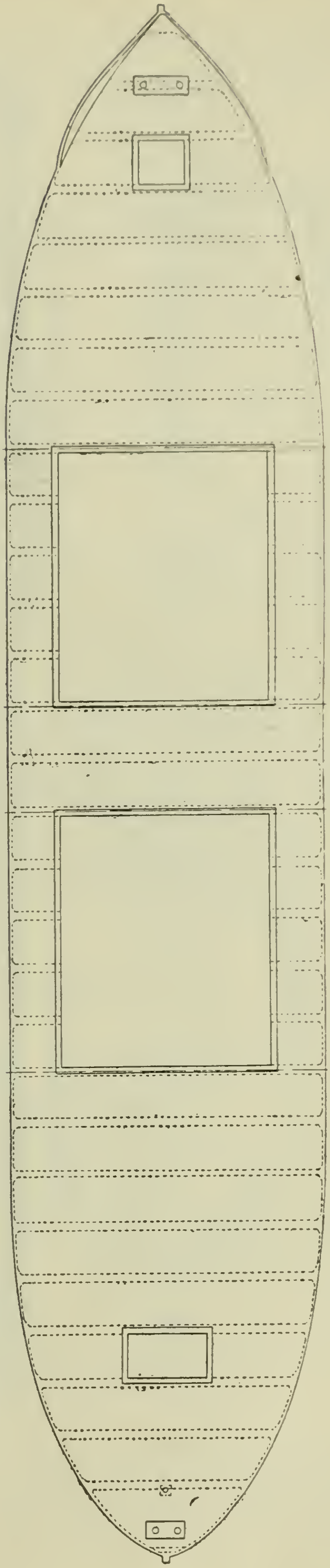


Fig. 139. Plan of Vessel.

being stiffened horizontally by a series of slabs placed at different levels according to the position of the compartment in which they occur. The reinforcement is arranged in accordance with the system usually employed by M. Considère, stirrups being placed wherever the shearing stress is likely to exceed 70 lb. per sq. in. The engine beds and other foundations for the machinery are made at the same time as the corresponding portions of the vessel.

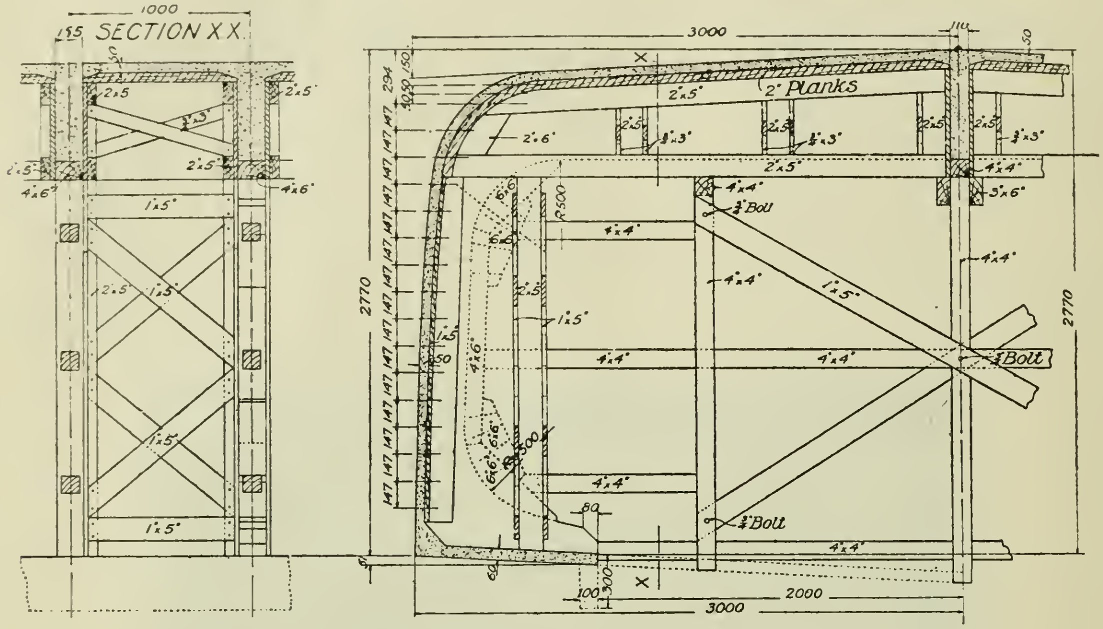


Fig. 140. Framework for Casting Rib 18.

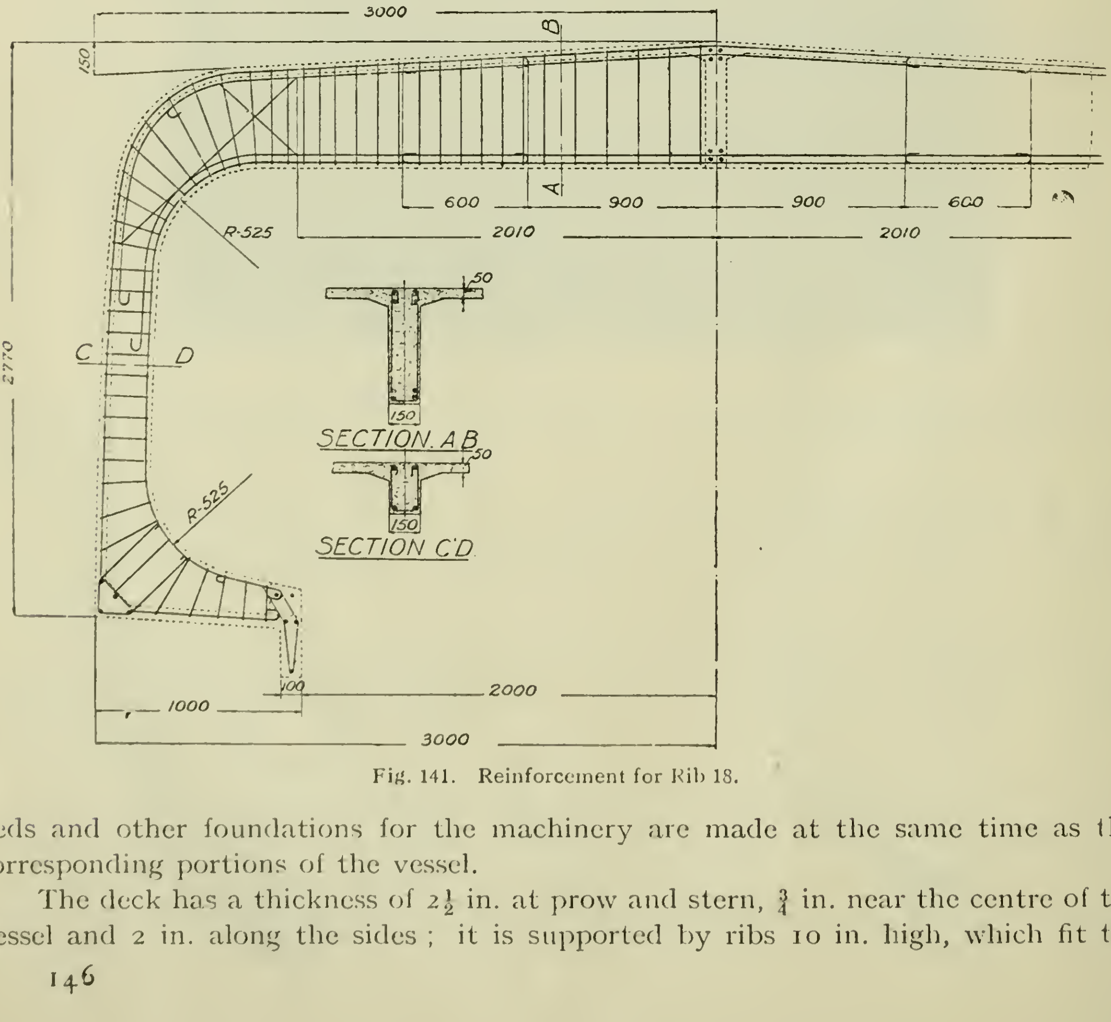


Fig. 141. Reinforcement for Rib 18.

The deck has a thickness of 2½ in. at prow and stern, ¾ in. near the centre of the vessel and 2 in. along the sides; it is supported by ribs 10 in. high, which fit the

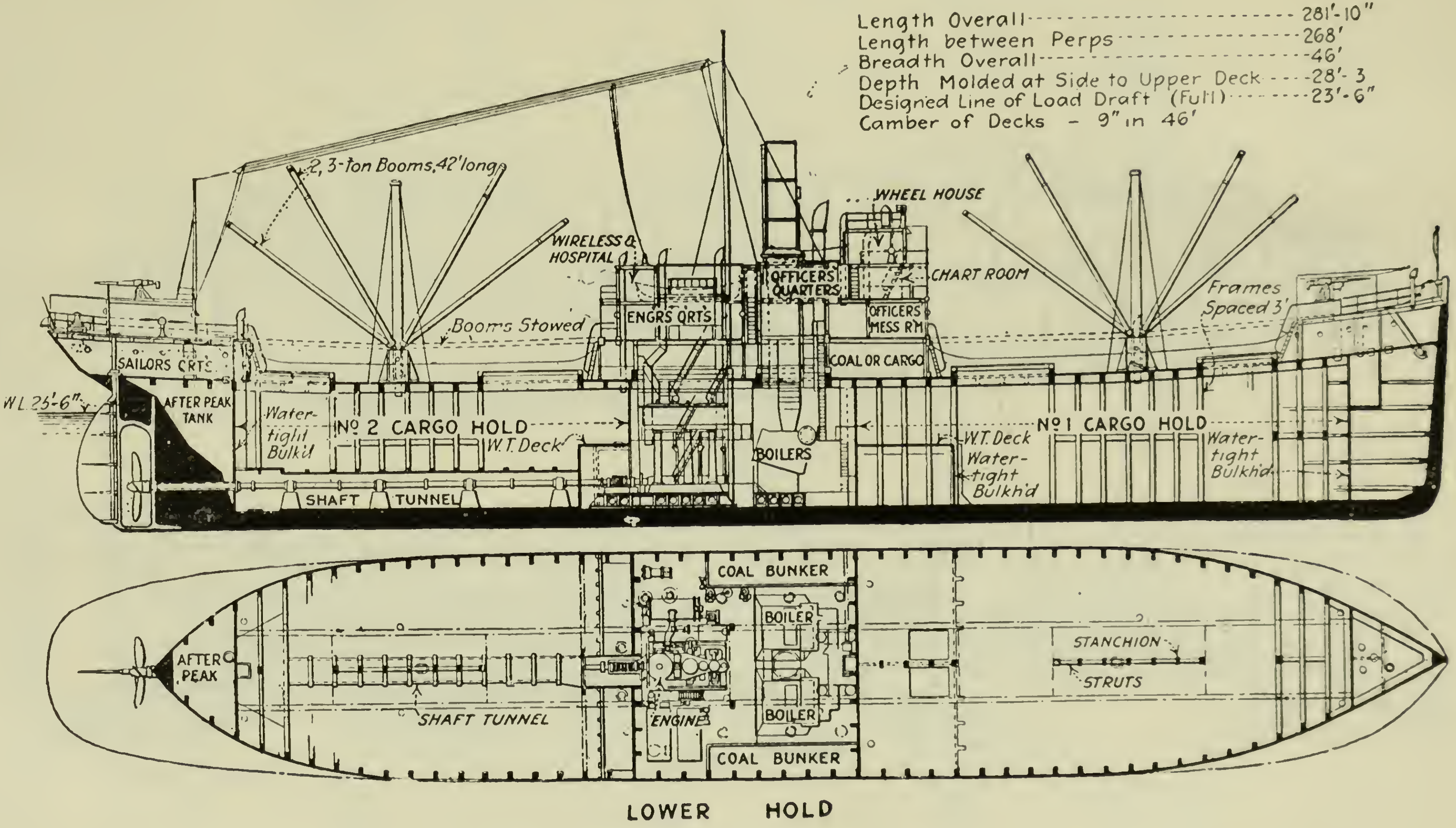


Fig. 142. American Concrete Ship Design.—Lower Hold

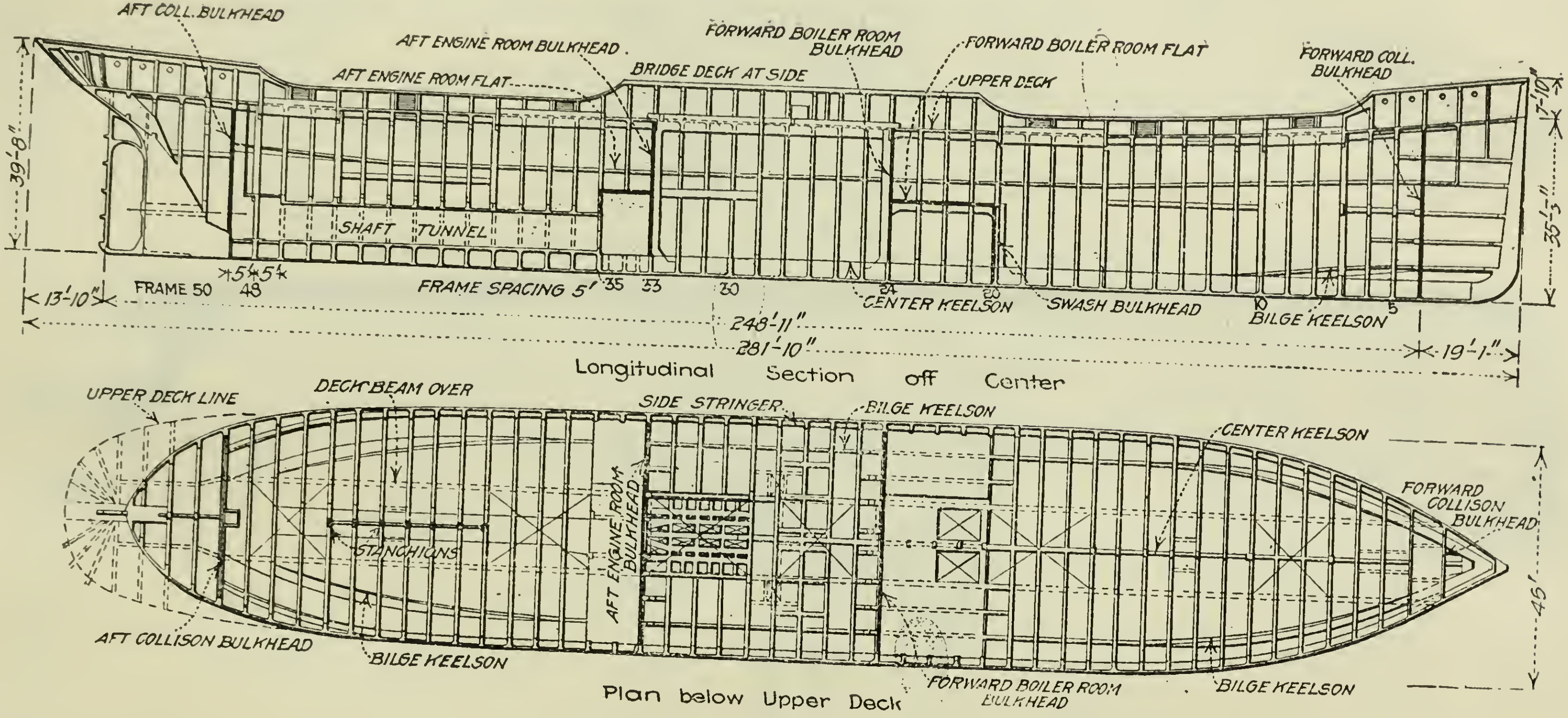


Fig. 143. Concrete Framing in 3,500-ton Concrete Ship.—Adaptation of simple beam and slab design.

vertical ribs previously mentioned. In the deck are four openings, measuring respectively 5 ft. 8 in. by 8 ft. 4 in., 6 ft. 3 in. by 9 ft. 10 in., 16 ft. 8 in. by 9 ft. 10 in., and 19 ft. by 9 ft. 6 in.

The keel is of concrete with a steel casing. The stern is reduced to a simple support for the rudder and the propeller.

These vessels have been designed to withstand an external pressure of 500 lb. per sq. ft. at the rim without any allowance for their weight. A similar allowance is made for the body of the vessel. The deck is designed to carry a load of 200 lb. per sq. ft. In accordance with naval regulations, the vessel is calculated to withstand a longitudinal moment of flexion of $\frac{PL}{30}$ where L is the length between the perpendiculars and P the total weight.

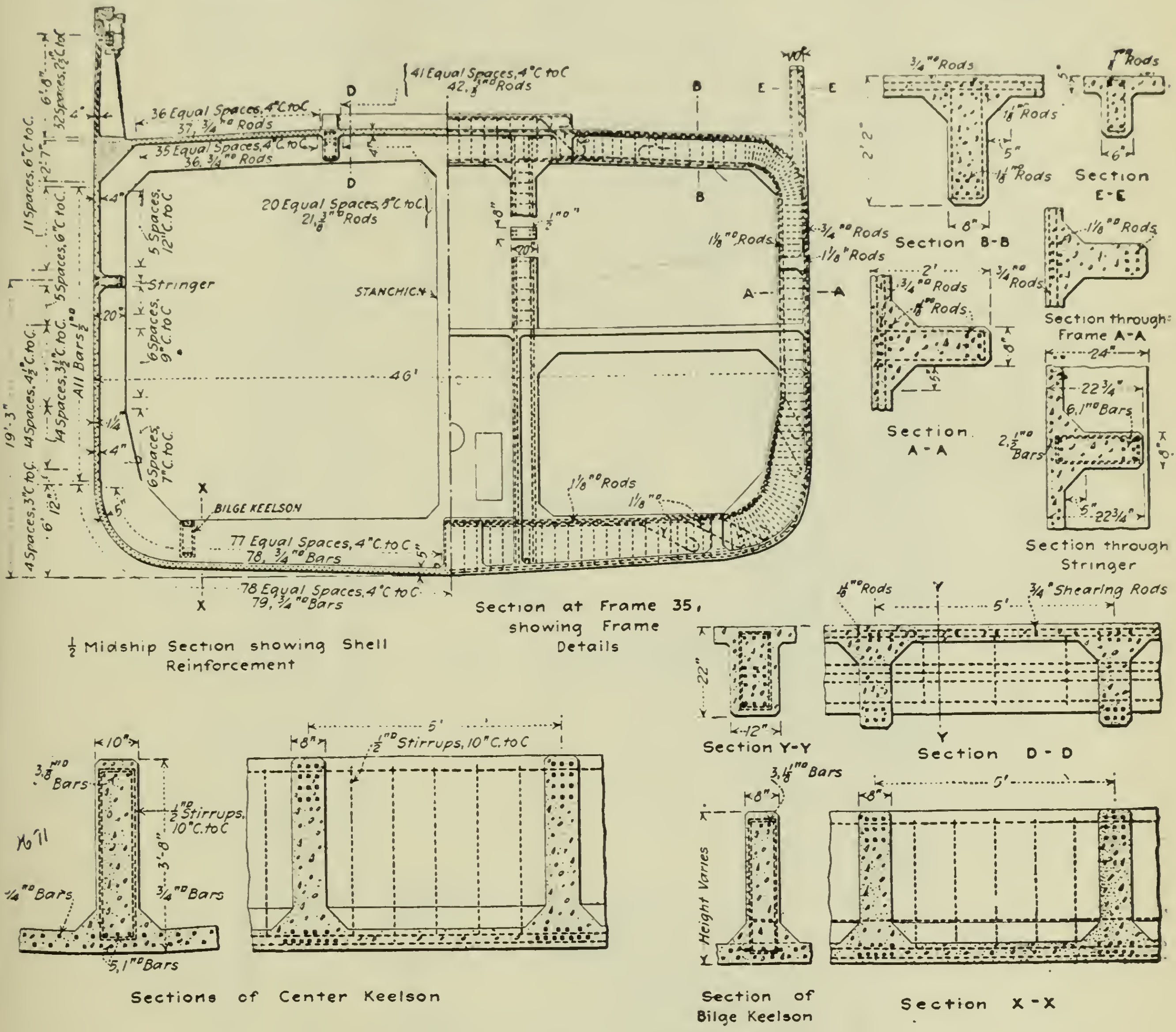


Fig. 144. Cross Frames and Shell in one of the Midship Sections.

The builders are willing to undertake contracts to deliver ten of these boats per month, the first delivery to take place not more than three months after the receipt of the order. They have hitherto been able to fulfil such engagements without difficulty

The construction of a 200-ton motor-driven towing boat designed by Messrs. Bonde & Norman and built by the Porsgrund Cementstöperi A/S of Porsgrund, Norway, is shown in *Figs.* 138-141. The measurements in *Figs.* 133 *and* 134 are given in 25ths of an inch (mm.).

Tug boats are very liable to collisions with piers, pillars of bridges and other obstacles, and they must therefore be designed so as to offer the maximum of resistance. Reinforced concrete offers exceptional advantages for this purpose, and as the amount of vibration transmitted from the engines and propeller to the vessel is inversely proportional to the inertia of the mass of the latter it will be seen that the use of concrete for towing boats is especially worth attention.

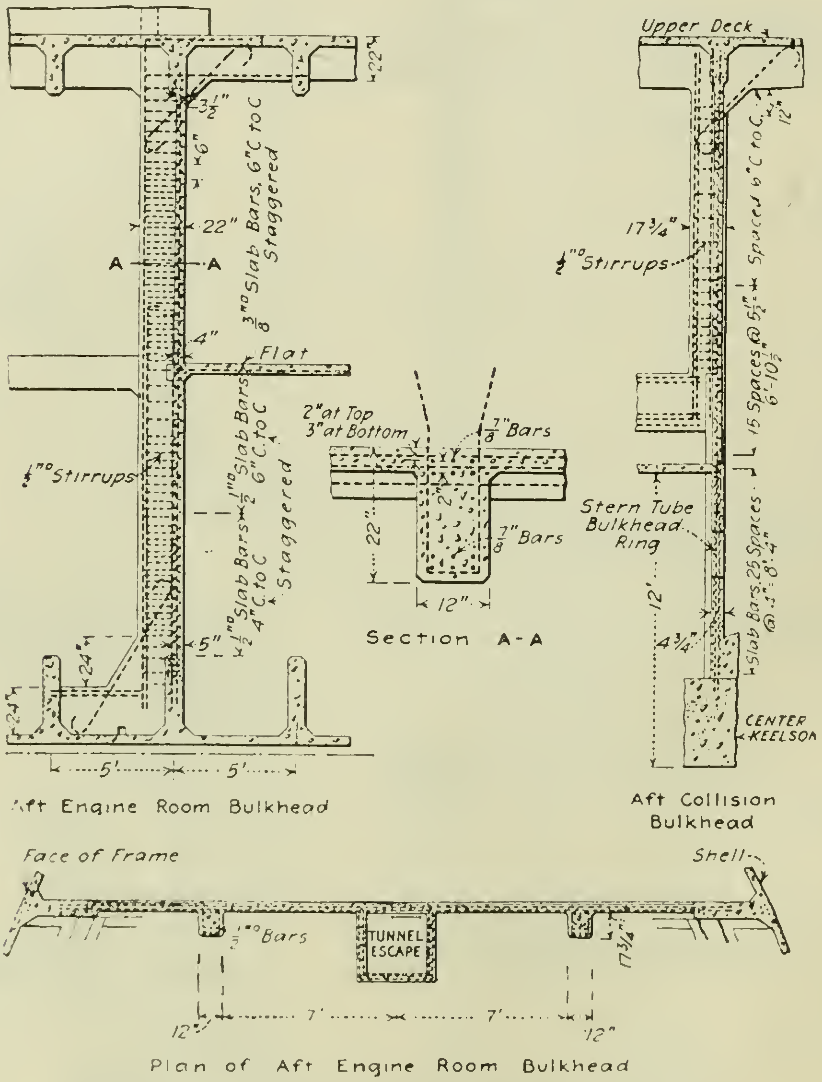


Fig. 145. Bulkhead Design to take full head of water inside vessel.

In the self-propelling vessels (*Figs.* 142-146) being built by the United States Shipping Board, Emergency Fleet Corporation the general shaping of the hull is practically the same as that of standard wooden ships. The midship section, which continues for about 35 per cent. of the length, is practically square. There is a slight batter in the bridge deck bulwark, and a rise of 9 in. in the bottom from the centre to the bilge keelsons.

Stiffness of the bottom is aided by one centre keelson and two bilge keelsons, the former turning to make stern and stem posts and the latter following the curve of

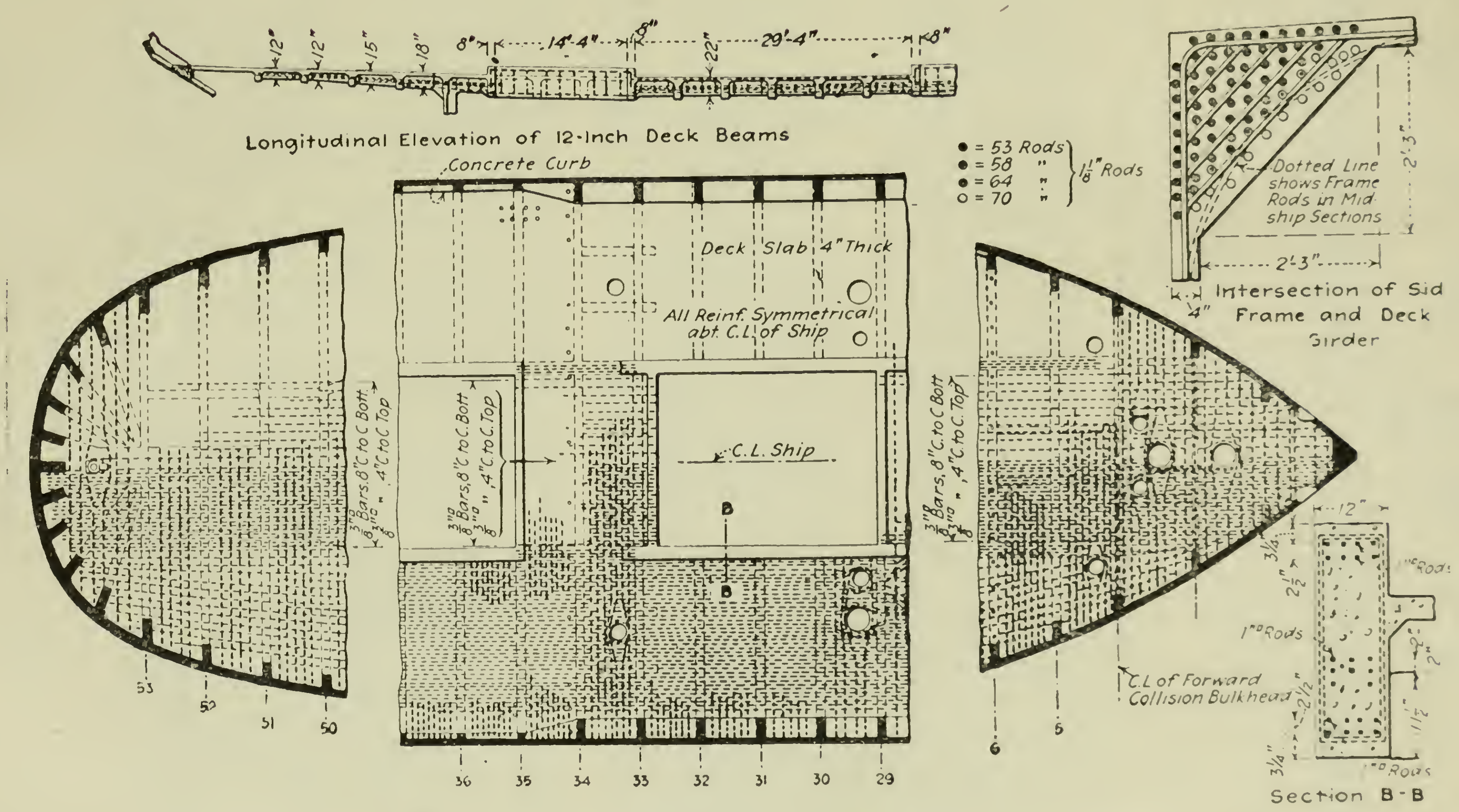


Fig. 146. Main Deck Reinforcement and Details similar to ordinary Reinforced Concrete Floor.

the hull and ending at the collision bulkheads. These keelsons are concrete girders reinforced with rods in their upper and lower sections and tied together with frequently spaced stirrups. They frame into the transverse frames of the vessel, which are spaced 5 ft. apart on centres. These frames (*Fig.* 144) are reinforced concrete girders turned at the corners to meet the curve of the hull and re-entering at the main deck to form the transverse deck girders which carry the deck and serve as cross-braces for the side members of the frames. The bridge deck bulwark is in effect a continuation upward of the shell of the ship, being formed of girder frames and an outer shell. It is provided with an expansion joint about midships. The main frames are additionally stiffened by longitudinal, horizontally-placed stringers about three-quarters of the way up the frame.

The shell is a continuous reinforced concrete plating, 5 in. thick on the bottom and up to a point 6 ft. above the base line, and 4 in. thick through the remainder of the hull to the deck line.

It is reinforced at its outer and inner faces with ½ in. to ¾ in. square bars running around the shell parallel to the water line and spaced at distances varying from 4 in. to 12 in., centre to centre. These rods are designed to be placed 1¼ in. from the face of the concrete on both outer and inner faces (*Fig.* 145). In addition, there are vertical ¾ in. shear bars between the horizontal rods spaced on varying centres. They extend around the entire shell and deck. The main deck is also a 4 in. reinforced concrete slab, continuous except for the hatch openings, which are stiffened by the usual combings (*Fig.* 146).

Between hatches in the cargo holds the deck beams have intermediate supports in the way of reinforced concrete stanchions designed as columns, these stanchions being braced longitudinally at about half their height with reinforced concrete struts. In the stern half of the boat the shaft tunnel is of reinforced concrete framing and the stanchions are supported on the cross-beams in the shaft-tunnel roof, which in turn span between short posts on either side of the tunnel.

Foundations for the engines and the boilers are on steel-plate girders footing on an extra framing of longitudinal reinforced concrete girders running parallel to the keelsons.

Four transverse watertight bulkheads are provided. Two are collision bulkheads near the bow and the stern, and two enclose the engine-room space. Details of these bulkheads are given in *Fig.* 146. They consist of concrete slabs reinforced with transverse and longitudinal steel, and backing against vertical stringers and beams which frame into the main frames and deck girders. The engine-room bulkheads are slabs stiffened by vertical beams extending from short stringers in the bottom between two frames to similar stringers framing into the deck beams.

For all conditions of loading the frames were designed to have stresses not to exceed 16,000 lb. per sq. in. in the steel and 1,500 lb. per sq. in. compression in the concrete. The bulkheads (*Fig.* 146) were designed to carry a head of water on either side up to deck. The collision bulkheads fore and aft were designed for 1,500 lb. per sq. in. in the concrete and 16,000 lb. per sq. in. in the steel. Steel stress in the engine-room bulkheads was advanced to 20,000 lb. per sq. in. The deck was designed to carry 5 ft. of water, or its equivalent, which is somewhat in excess of the loading on the decks of standard steel ships being built by the Emergency Fleet Corporation.

(To be continued.)

Continued page 369 of Concrete & Const. Engineering

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

THE GEOLOGY OF CONCRETE AGGREGATES.

IN placing before our readers in this issue of CONCRETE a summary of Professor Boswell's recent paper on "The Geology of Sands and Aggregates," we hope to direct attention to, and arouse interest in, a group of methods of investigation which, in their application to the constituents of concrete, are comparatively new. In furtherance of this purpose we propose to supplement Professor Boswell's treatment of the subject by a general discussion of its scope and significance. At the outset we shall do well to consider what is meant by the "geology" of aggregates. Geology is by no means confined to the field study of rock-formations, although, as such formations are the architectural units of the earth's crust, it is necessarily by their investigation that the geologist arrives at his most fundamental results, and builds up the details of the long and varied history which it is his object to elucidate. Concrete workers are not primarily interested in rocks as documents of geological history, but they are intimately concerned with the distribution and resources of the materials they employ, and this is a subject on which the geologist, by his special experience, is in a position to speak authoritatively.

But the scope of his work is much more detailed than this, for a necessary complement to field-work is the examination of representative rock specimens in the laboratory. Here the geologist has devised a series of methods of research which consist essentially of the application of physics and chemistry to the solution of the special problems which he desires to solve. Stated in the most general way, these problems involve the determination as accurately as possible of the present condition of any given rock, expressed in terms of mineral or chemical composition, structure, and texture, and the deduction by analogy or experiment of its mode of origin, and its liability under different circumstances to alteration or decay. All of these topics are of particular interest to the concrete worker, and the geologist, by the application of methods which he has made his own, should, therefore, be able to solve many of the problems associated with aggregates, and to guide the architect or engineer in the choice of the materials which, among those available, are most suitable for any given purpose.

Concrete is often a highly complex mixture, and the effects of weathering may be correspondingly complicated, particularly when the concrete is reinforced or otherwise associated with metals. Rain, as well as the moisture of the original mixture, promotes hydration, and may, with the aid of dissolved gases, salts, or acids, bring about changes that are sometimes advantageous, but more commonly deleterious to the structure. The gases of the atmosphere promote oxidation, and help effectively in the processes of solution, especially in large industrial centres where traces of corrosive fumes add their disintegrating force to the gentler agents of nature. The behaviour and alteration of sulphides and the solutions formed from them and from sulphates require special investigation, more particularly from the point of view of their effects on steel-work, cement, and certain types of aggregates, and the relation of these effects to corrosion on the one hand, and the development of disruptive stresses through expansion, on the other. The geologist is well acquainted with the action of sea water on various types of rocks, and is therefore in a position to indicate its action, and that of salt-water—where this is used in contact with floors—on the materials present in any given variety of concrete. In all these, and other similar problems, the geologist must bring to his aid a considerable fund of chemical ability.

On the physical side the problems that arise include those connected with changes due to temperature variation ; changes which ordinarily proceed almost imperceptibly, but which in industrial operations involving heat, and most spectacularly in the case of conflagrations, may lead to localised structural damage, or to wholesale destruction. Other problems are those associated with surface-tension, which need to be considered in connection with the making and setting of concrete ; and here the geologist is able to help by microscopic studies of structure, of the relation of surfaces to porosity and adhesion, and of the shapes and sizes of the particles of fine stuff present in the aggregates, whether due to crushing, inadequate washing, friability or alteration-products.

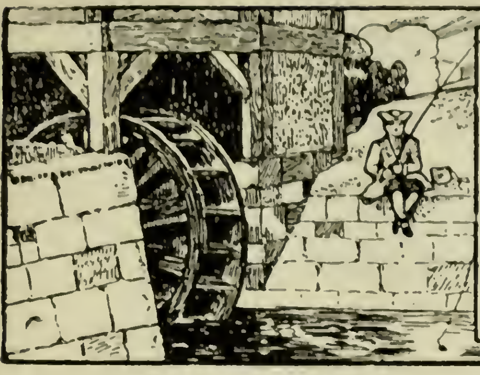
It will be clear from the preceding discussion that geological methods of research need not be confined to natural aggregates, such as sand, gravels, and crushed rocks, or to the raw materials from which artificial aggregates, such as slags, and bricks, are derived. Not only are the artificial aggregates natural in their ultimate origin, and " artificial " only in so far as they have been altered by the action of heat, but somewhat similar materials have been produced naturally by the action of heat generated within the earth on the raw materials, like coal, clays and shales, from which our coke-breeze, clinkers, burnt clays and bricks are derivatives. In the case of slags the resemblance to certain basic lavas is so marked that, although they have no field-geology, they can be described in the same terms as lavas, and their study has, in fact, been of great service to the geologist in his interpretation of many of the phenomena exhibited by lavas. Moreover, from the purely practical point of view, it is necessary to investigate artificial aggregates in precisely the same ways as those of immediately natural origin, and the results, whether embodied in descriptions, specifications or generalisations, cannot fail to serve as a basis for identification and comparison, and for the better comprehension of the qualities, good or bad, which control the behaviour of different classes of aggregates under the various circumstances that may befall a concrete structure during its life-history. It need not, therefore, be considered an unjustifiable extension of the field covered by the " geology " of aggregates to bring also the artificial aggregates within its boundaries.

In the above paragraph we have referred to the description and identification of aggregates, and to this part of the subject Professor Boswell devotes considerable attention, since it is necessarily the part on which every geologist can be of immediate assistance. The fundamental features of aggregates as materials are their mineral composition, their broader structures, and their more detailed—often microscopic—textures, and these can rarely be wholly determined without the examination of thin sections under the petrological microscope. The mineral composition points to the chemical suitability or otherwise of the material for its allotted purpose, while the structures and textures indicate the strength and toughness of the material, the way it will break, its homogeneity or variability, its grain size—a matter of great importance in many respects—its penetrability by cement or by solutions, and therefore its capacity for withstanding disintegration. Finally, in many cases, only an adequate examination or description on these lines can lead to an accurate identification of the material.

It is obvious that it is of little use to gain information about the behaviour of aggregates either by controlled experiments or special investigations, or from actual experience with concrete structures themselves, unless the materials concerned are accurately described and properly named. Otherwise the information cannot be applied to other materials of a similar nature, nor can it be used as a means of future guidance. The question of nomenclature is thus one of far more than academic importance. In particular it is strongly to be urged that specifications should describe and name materials with sufficient detail and discrimination to avoid the misconceptions that surround many of the commercial terms unfortunately in common use. Terms like *ballast*, *granite*, and *trap-rock*, unless qualified or otherwise made unequivocal, are often quite misleading. Ballast does not mean only " Thames ballast " (flint gravel) but it also includes gravels composed of quartzite, sandstone, limestone, granite, and other pebbles. One type of pebble may predominate, and the aggregate, especially if crushed, is then equivalent to one composed of crushed fragments of the rock-type represented. Many gravels, however, are of a composite nature, and are then equivalent to a correspondingly mixed aggregate. As a commercial term " granite ' is applied not only to granite in its broadest geological sense, or to rocks like diorite and gneiss, but also to rocks as different from these as limestone, quartzite or schist (sedimentary and metamorphic), and dolerite, and other igneous rocks. It thus overlaps in meaning with " whinstone " another common term, which includes dolerites and basalts, and similar dark, fine-grained igneous rocks. The term " trap," is unfortunately so widely applied as to be of very little descriptive value. It includes not only the whinstones, and their altered analogues, the greenstones, but also a miscellaneous series of other types which may behave very differently as aggregates. Less than a score of names would, with suitable mineralogical and structural prefixes, be adequate to designate for most purposes the majority of the chief rocks used for concrete—provided always that they were properly applied. Surely it is desirable that those in charge of concrete work should know these terms and the chief properties which their application to a rock implies.

Professor Boswell directs attention to an important aspect of his subject in dealing with the shapes, sizes and grading of aggregates, an aspect which he explores more closely in his treatment of sands, on which he is a recognised authority. Unfortunately space does not here permit any further discussion of the problems involved. On one point, however, we must take exception to a suggestion thrown out by Professor Boswell. He rightly considers that the gradation of sizes of the fragments of the aggregate and sand together should be as perfect as possible. But when he suggests that the aggregate should be screened down to particles as small as $\frac{1}{50}$ inch, and that sand of finer grades than this should then be added, he is proposing a quite impracticable method for arriving at a result which is ordinarily obtained with much greater ease. In practice, coarse aggregates are not generally screened down to less than $\frac{1}{4}$ or $\frac{3}{16}$ inch, and the smaller grades are added in the form of sand, which, in terms of Professor Boswell's notation, includes grades ranging from gravel, through very coarse, coarse, and medium sand to fine sand. The commercial significance of the term "sand" does not quite coincide with the meaning given to it by the geologist, but that need cause no confusion, since it is easy to speak of the "sand grade" or of the "coarse sand grade," etc., whenever it is necessary to specify or refer to particular limits of size.

Professor Boswell merits our gratitude for having discussed in a short space a wide variety of geological topics in their relation to concrete. His concluding suggestion, that more detailed knowledge is required of the British resources of the materials employed, deserves especially to be emphasised. The task implied is one essentially for the geologist, and many of the results, when obtained, might advantageously be embodied in the Home Office *List of Quarries*, a publication which would be more generally serviceable if the rocks mentioned in connection with each quarry were described in geological as well as commercial terms.



REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

By ERNEST G. W. SOUSTER, A.R.I.B.A.

The design of the new reservoirs at Montevideo possesses several interesting features and proves the adaptability of reinforced concrete for economically overcoming the difficulties inherent to this type of structure.—ED.

GENERALLY.

MONTEVIDEO, as is well known, is the capital city and the chief port of the Republic of Uruguay, and its growth during recent years has been continuous and increasing. Although the city has an age of about 200 years, it was not until 1879 that the Montevideo Waterworks Co., Ltd., was formed to give a constant supply of water for the needs of the population. Previous to this time water butts and surface wells had been the only supply, but with a proper system the consumption has continuously increased and the necessity of providing for storage in case of emergency led the company to construct additional reservoirs which are the subject of this article.

The water supply of the city is obtained from the Santa Lucia River, a tributary of the River Plate and the intake of the water is about 34 miles from the city itself. As the water carries a large quantity of microscopic alluvial matter in suspension it is treated with alluminoferric salts, filtered and then pumped through steel and cast-iron mains to the reservoirs, which are formed at Las Piedras, about 12 miles from the city and about 300 ft. above the normal level of Montevideo.

When, in 1914, the construction of the works was decided upon, their design and erection being entrusted to the Hon. R. C. Parsons, after due consideration a scheme for two separate reservoirs constructed entirely of reinforced concrete was adopted.

Each of these reservoirs is approximately of 6,500,000 gals. capacity, their dimensions being 64 m. by 64 m. and 64 m. by 54 m., with depths of 17.27 m. for the former and 18.77 m. for the latter, the floors of both being at the same level.

The site on which they are built is granite, which has become disintegrated by atmospheric conditions and is intersected by fissures which needed to be bridged over with reinforced concrete before the reservoir floors could be laid.

Concrete filling was also necessary in certain places where patches of softer material occurred, and to eliminate danger from underground springs and to carry off water that might arise from temperature leaks in the floors a system of drains was laid near the footings of floors, as is indicated on the plan *Fig.* 1, which shows the general arrangement of the whole scheme.

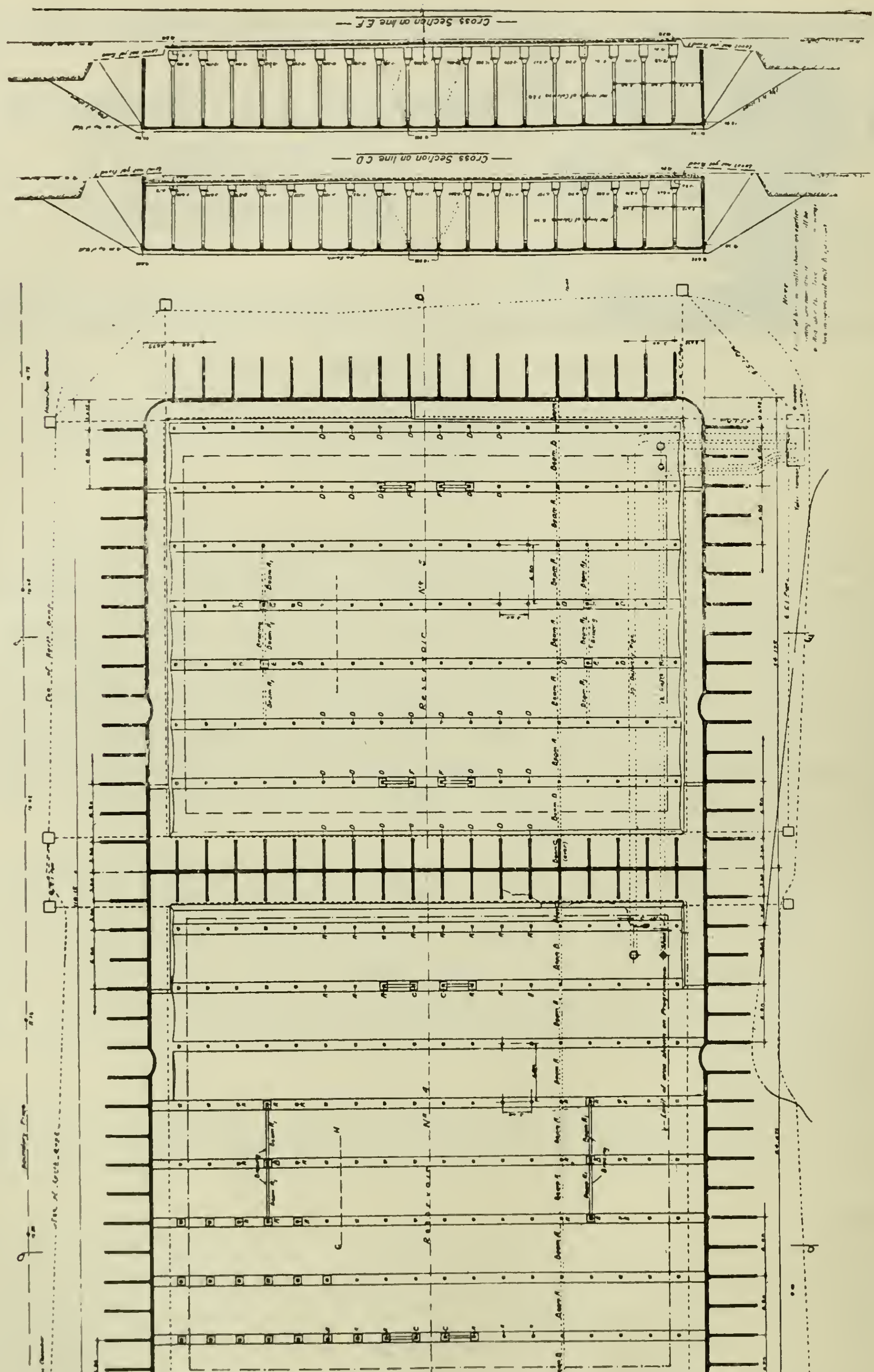


FIG. 1. General Plan.
REINFORCED CONCRETE RESERVOIRS AT MONTEVIDEO.

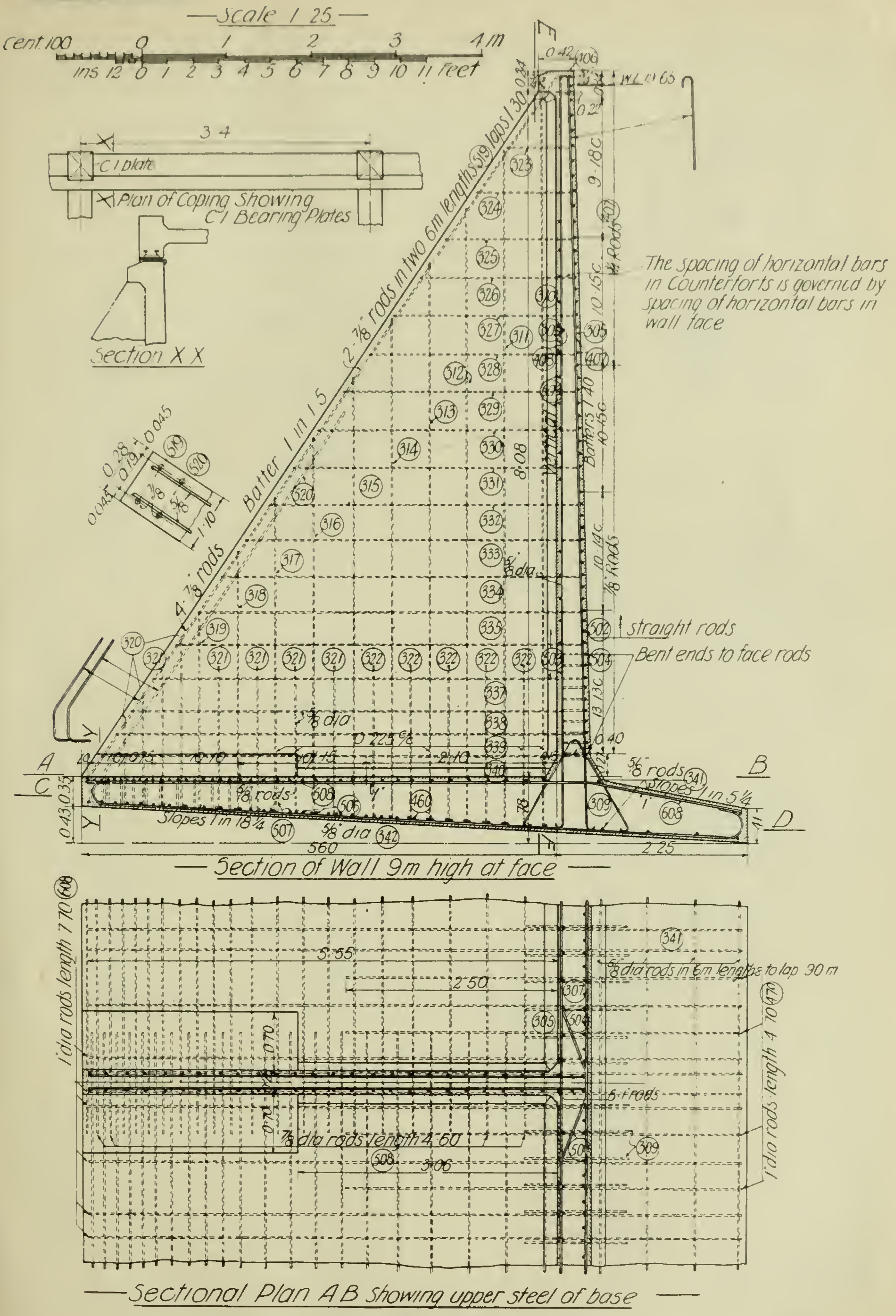

Scale 1/25
Cent. 100 0 1 2 3 4 m
ins 12 0 1 2 3 4 5 6 7 8 9 10 11 feet
3·4
C I plate
X Plan of Coping Showing C I Bearing Plates
Section X X
0.28 0.19 0.045
0.045
⅞ ⅝
1·10
Batter 1 in 1.5
4-⅞ rods
(2-⅞ rods in two 6 m lengths (519) laps 1·30 0.34
0.42 (106)
W.L. 10.65
0.27
9·18c
(201) ¾ rods
The spacing of horizontal bars in Counterforts is governed by spacing of horizontal bars in wall face
10·15c
Batters 1 40
10·16c
Vertical
8·08
10·14c
⅞ rods
⅝ dia
straight rods
Bent ends to face rods
13·13c
0.40
⅝ dia
0 225 %
2·10
⅝ rods
Slopes 1 in 5¼
Slopes 1 in 18¼
⅝ dia
A B C D Y
0.43 0.35
560
2·25
Section of Wall 9m high at face
1 dia rods length 7·70 (608)
5·55
2·50
(341)
⅞ dia rods in 6m lengths to lap 90 m
1 dia rods length 4·70 (470)
0·70
5-1 rods
⅞ dia rods length 4·60
3·06
Sectional Plan AB Showing upper steel of base

FIG. 2. Detail of External Buttresses.
REINFORCED CONCRETE RESERVOIRS, MONTEVIDEO.

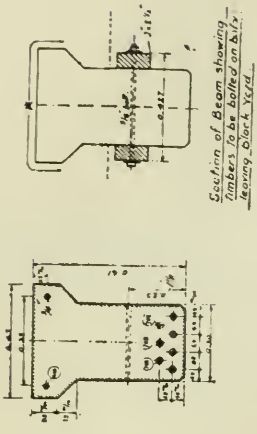
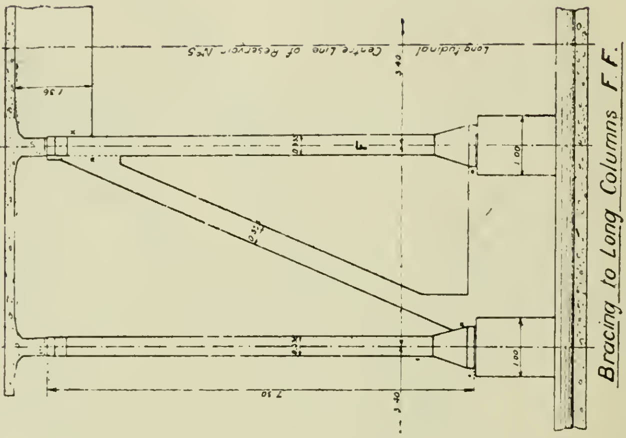
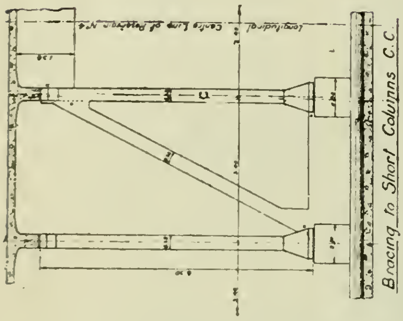

Section of Beam showing timbers to be bolted on bolts leaving block Yard

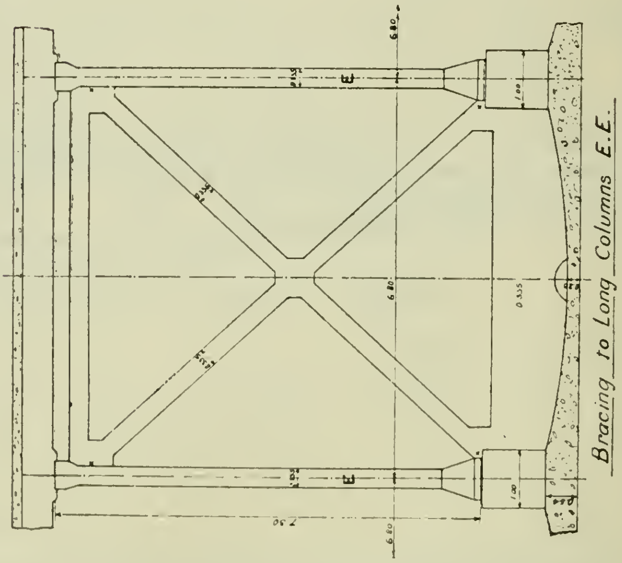
FIG. 3a. Details of Beam.



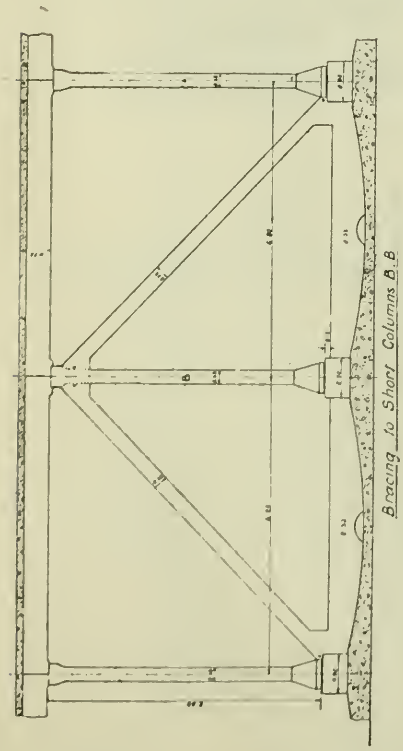
Bracing to Long Columns F.F.



Bracing to Short Columns C.C.



Bracing to Long Columns E.E.



Bracing to Short Columns B.B

FIG. 3. Column Details, showing bracings to prevent movement.
REINFORCED CONCRETE RESERVOIRS, MONTEVIDEO.

As will be seen from this drawing, the two reservoirs are divided by a wall designed and buttressed on either side to withstand all possible pressures from water in either or both divisions.

The plan shows that the reservoirs are set out on a unit base of 6·8 m. by 3·4 m. except on outer sides and against division wall where varying spacing is adopted, and on these intersecting points bases are formed to receive the columns carrying the roof.

The floors between each row of column bases (see *Fig.* 3) are dished to a radius of 11·7 m., and this dishing is formed to gradually fall to the cleaning outlets.

Upon the bases, reinforced concrete columns 6·8 m. long are fixed to support the main girders carrying the roof, which is monolithic over each reservoir and which, at its outer edge, is formed into a continuous beam resting on sliding plates to allow for movement arising from the changes of temperature inseparable from the climatic conditions of the country.

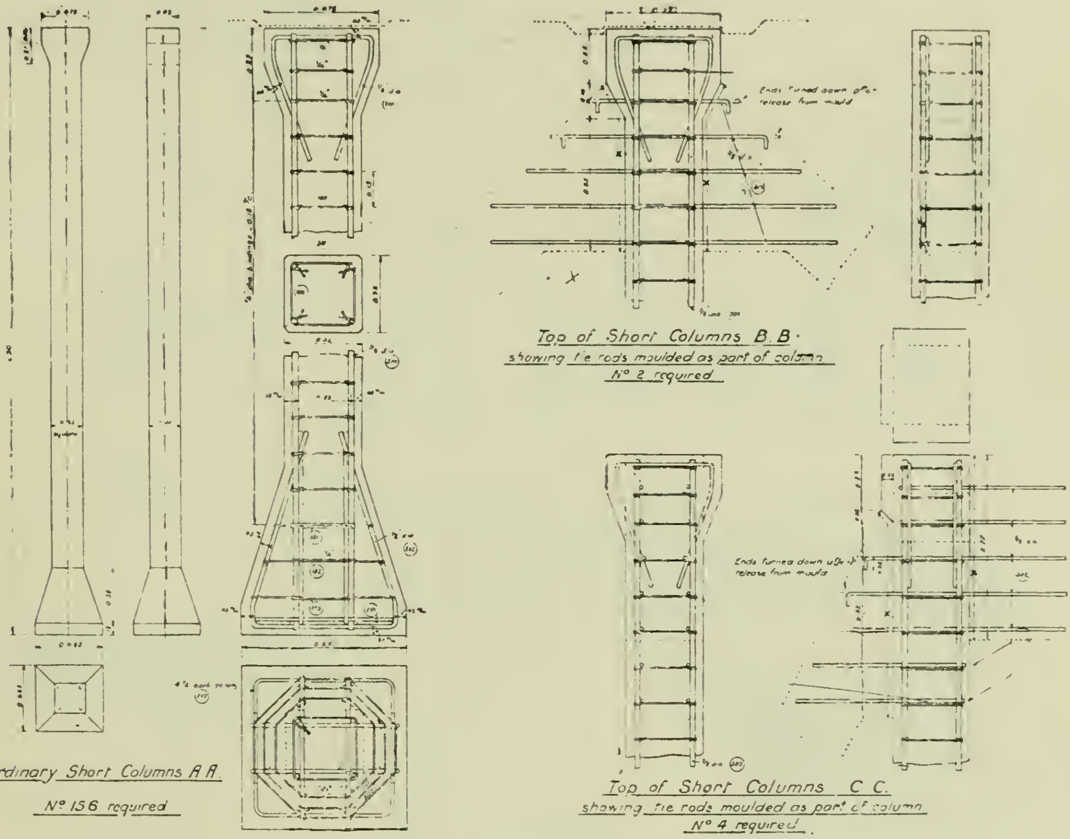

Ordinary Short Columns A A.
No 156 required
Top of Short Columns B B.
showing tie rods moulded as part of column
No 2 required
Ends turned down after release from mould
Top of Short Columns C C.
showing tie rods moulded as part of column
No 4 required
Ends turned down after release from mould

FIG. 4. Column Details.
REINFORCED CONCRETE RESERVOIRS, MONTEVIDEO.

Throughout the design and construction of the work all possible means were taken to avoid the risk of cracks arising from expansion and contraction, and the system of lattices or bracings shown in *Fig.* 3 effectively prevent any displacement of the roof from its normal position. The design of these features is well worthy of study and, as will be seen from *Figs.* 1 and 3, additional strength is given to them by making them monolithic to the supporting piers and by joining these latter by a reinforced dwarf wall.

In the outer walls still further precautions were taken to remove possibilities of cracks which might arise from expansion, contraction and water pressures.

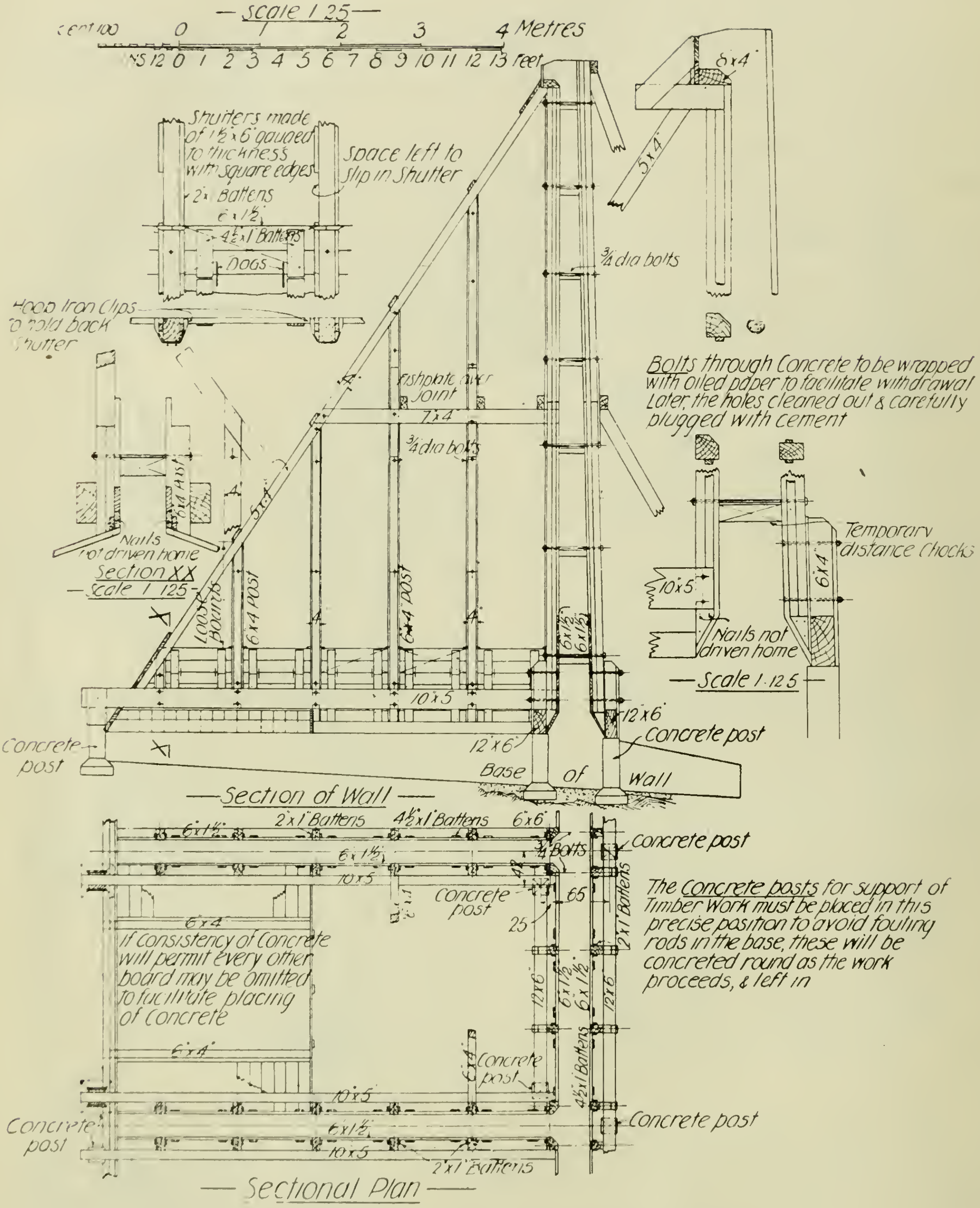

— Scale 1 25 —
cent 100 0 1 2 3 4 Metres
ns 12 0 1 2 3 4 5 6 7 8 9 10 11 12 13 feet
Shutters made of 1½ x 6" gauged to thickness with square edges
Space left to slip in Shutter
2" Battens
6 x 1½"
4½ x 1 Battens
Dogs
Hoop Iron Clips to hold back Shutter
8 x 4"
5 x 4"
¾ dia bolts
Fishplate over joint
7 x 4
¾ dia bolts
Bolts through Concrete to be wrapped with oiled paper to facilitate withdrawal Later, the holes cleaned out & carefully plugged with cement
Nails not driven home
Section XX
— Scale 1 125 —
Loose Boards
6 x 4 Post
6 x 4 Post
6 x 1½
6 x 1½
10 x 5
12 x 6
12 x 6
Concrete post
Concrete post
Base of Wall
Temporary distance Chocks
6 x 4"
10 x 5
Nails not driven home
— Scale 1·125 —
— Section of Wall —
6 x 1½
2 x 1 Battens
4½ x 1 Battens
6 x 6
¾ Bolts
Concrete post
6 x 1½
10 x 5
Concrete post
65
25
2 x 1 Battens
The Concrete posts for support of Timber Work must be placed in this precise position to avoid fouling rods in the base, these will be concreted round as the work proceeds, & left in
6 x 4
If consistency of Concrete will permit every other board may be omitted to facilitate placing of Concrete
12 x 6
6 x 1½
6 x 1½
12 x 6
6 x 4
6 x 4
Concrete post
4½ x 1 Battens
10 x 5
Concrete post
Concrete post
6 x 1½
10 x 5
2 x 1 Battens
— Sectional Plan —

Fig. 5. Detail showing Shuttering for External Buttresses.
Reinforced Concrete Reservoirs, Montevideo.

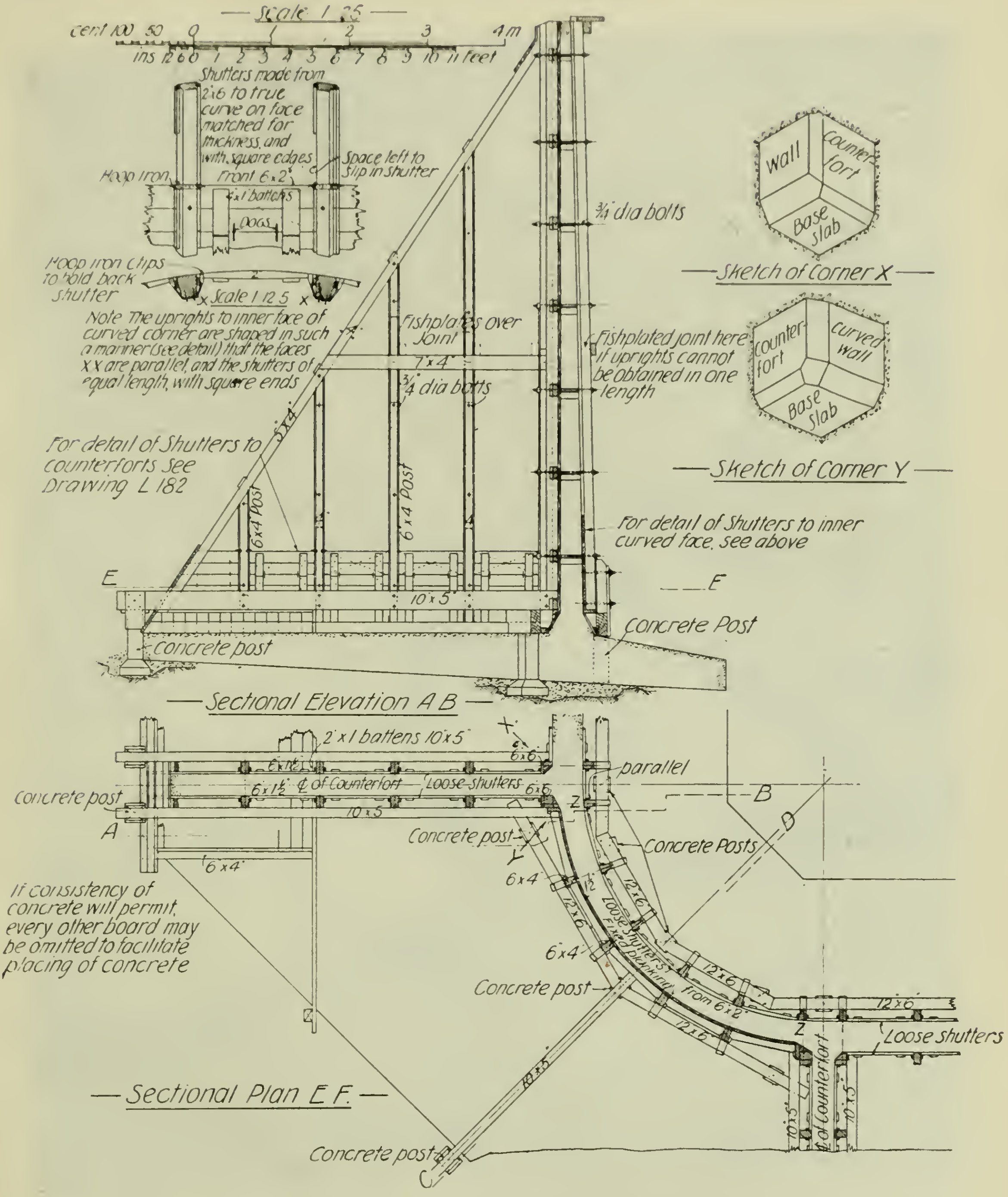

— Scale 1 25 —
cent 100 50 0 1 2 3 4 m
ins 12 6 0 1 2 3 4 5 6 7 8 9 10 11 feet
Shutters made from 2 x 6 to true curve on face matched for thickness, and with square edges
Space left to slip in Shutter
Hoop iron
Front 6 x 2
2 x 1 battens
Dogs
Hoop iron clips to hold back shutter
x Scale 1 12 5 x
Note The uprights to inner face of curved corner are shaped in such a manner (see detail) that the faces X X are parallel, and the shutters of equal length, with square ends
Fishplates over Joint
7 x 4
3/4 dia bolts
3/4 dia bolts
Fishplated joint here if uprights cannot be obtained in one length
5 x 4
For detail of Shutters to counterforts See Drawing L 182
6 x 4 Post
6 x 4 Post
For detail of Shutters to inner curved face, see above
E
F
10 x 5
Concrete Post
Concrete post
— Sectional Elevation A B —
Wall
Counterfort
Base slab
— Sketch of Corner X —
Counterfort
Curved wall
Base slab
— Sketch of Corner Y —
2 x 1 battens 10 x 5
X
6 x 6
6 x 1½
6 x 1½
℄ of Counterfort
Loose shutters
6 x 6
10 x 5
parallel
Z
B
D
Concrete post
A
Concrete post
X
Y
Concrete Posts
6 x 4
6 x 4
12 x 6
12 x 6
Loose Shutters
Fixed planking from 6 x 2
6 x 4
12 x 6
12 x 6
12 x 6
Concrete post
Z
Loose shutters
If consistency of concrete will permit, every other board may be omitted to facilitate placing of concrete
10 x 5
10 x 5
10 x 5
℄ of Counterfort
— Sectional Plan E F. —
Concrete post
C

Fig. 6. Details of Corners of Reservoirs.
Reinforced Concrete Reservoirs, Montevideo.

The most interesting feature of these precautions is the formation of segmental bays which eliminate all strains that might endanger the containing walls and which are fully illustrated in *Fig.* 13. In the construction of the work the spaces for these bays were left open and the segmental work was not built until after the adjoining straight walls had set and taken their bearings. At the corners also square angles were dispensed with and the walls joined by quadrant walls struck to a radius of 3·385 metres. See *Fig.* 6.

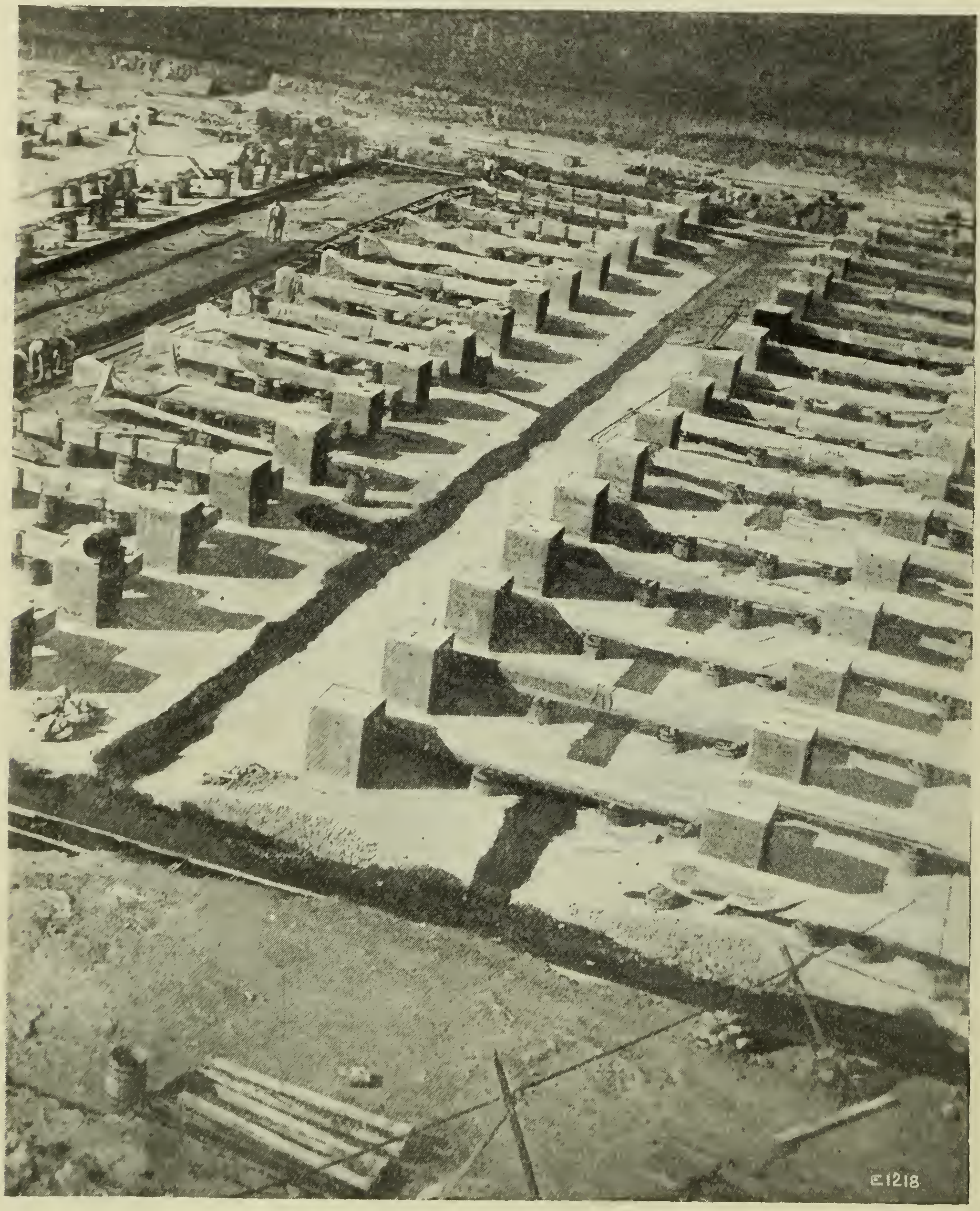


Fig. 7. Construction of Column Bases.
Reinforced Concrete Reservoirs, Montevideo.

Throughout the works the outer walls are so designed that no bar is stressed to more than 13,800 lb. per sq. in. or concrete compressed more than 650 lb. per in., and although the walls are externally backed by earth (see *Fig.* 1) no allowance was made for this in the design of the concrete work.

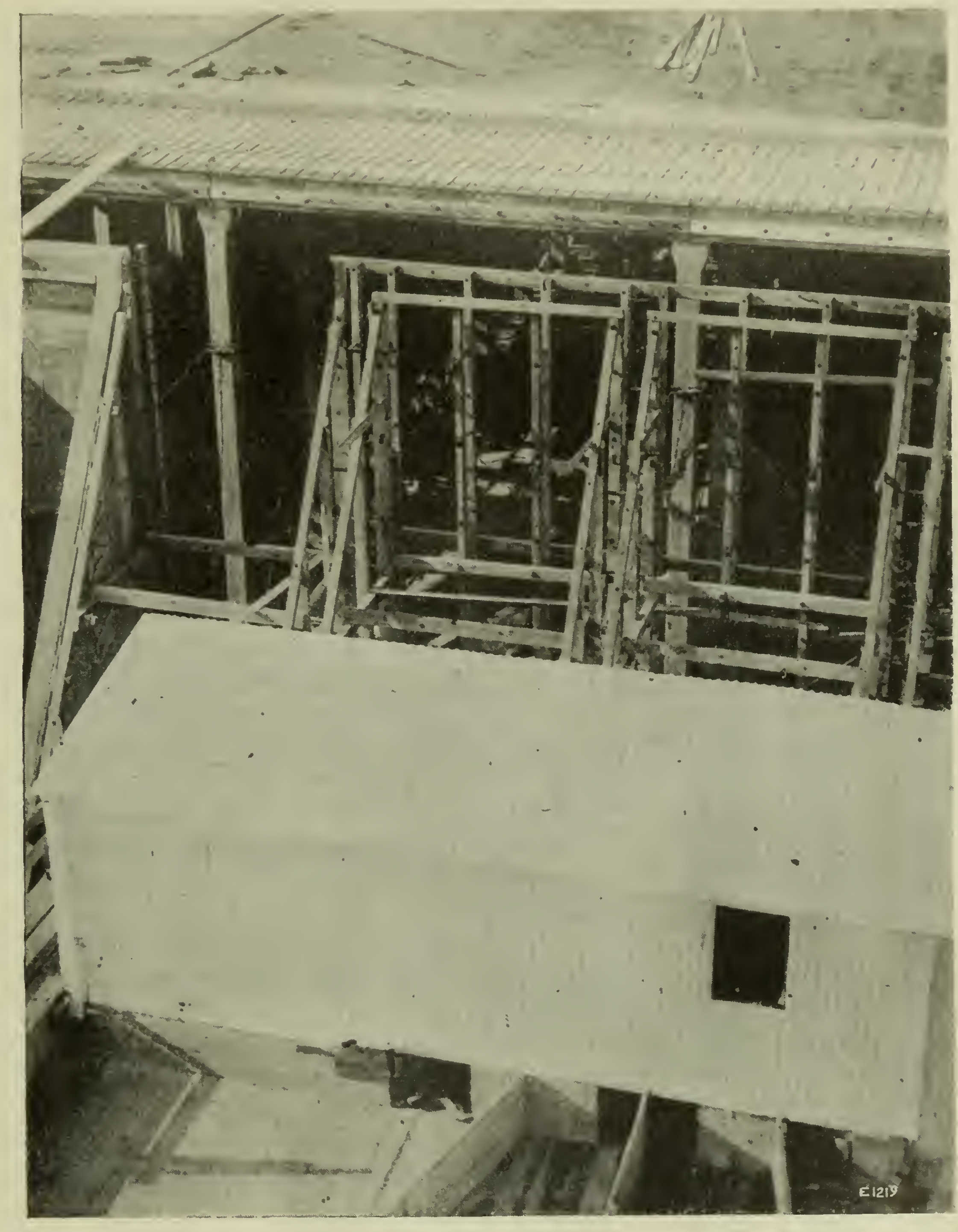


FIG. 8. Construction of Outer Wall.
REINFORCED CONCRETE RESERVOIRS, MONTEVIDEO.

On the roof of the structures a layer of earth, 40 m. in thickness, has been laid to protect the concrete from the heat of the sun and to carry off water that

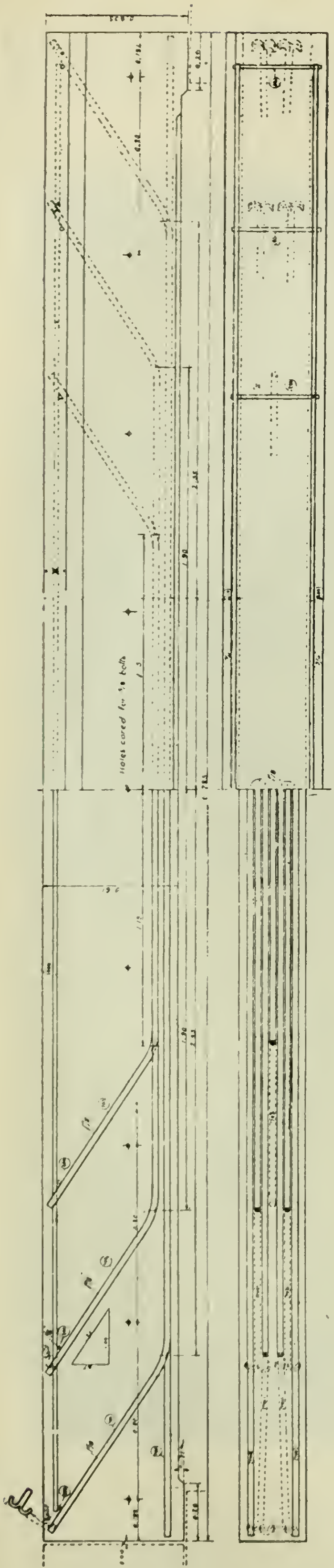


Fig. 9. Details of Roof Beams.
Reinforced Concrete Reservoirs, Montevideo.

may fall upon it during the rainy season, and surface drains connected with the general drains above-mentioned have been formed.

CONSTRUCTION.

The aggregate used for the work was hard granite from a quarry near to the site, but the sand had to be brought from a pit 25 miles away. The Portland cement was entirely of British manufacture made in accordance with the British Specification No. 12, and was of very slow-setting quality.

The proportions of the concrete in the works were as follows:—Floors: 1 cement, 2½ sand, 4½ broken granite (2-in. maximum cubes). Base of walls: 1 cement, 2 sand, 4 broken granite (2-in. maximum cubes). Walls: 1 cement, 2 sand, 3 broken granite (1-in. maximum cubes). Columns and beams: 1 cement, 2 sand, 3 broken granite (2-in. maximum cubes). Roofs: 1 cement, 2 sand, 4 broken granite (1-in. maximum cubes).

The steelwork was designed to be executed with ordinary mild steel, but owing to the war it was impossible to obtain deliveries and in many places "shell discard" or high-tensile indented bars were substituted. Exhaustive tests of the whole of the materials were made during the progress of the works and, in addition, the cement was tested before shipment, and again 28 days before it was used. From the results of these tests it was found that no signs of leakage occurred in specimens made to the specification, and accordingly the necessity of rendering the internal faces of the reservoirs was eliminated.

The shuttering, always a heavy cost in reinforced concrete work, was designed to be used again and again, but in all cases a minimum of 14 days was allowed to elapse before removal after the concrete was filled in, and, bearing in mind the decision to dispense with the usual rendering, the shuttering was very carefully fixed and soft soap used thereon to prevent adhesion between the cement and the boards.

The design of portions of the shuttering is seen in *Figs.* 5, 6 and 8, and it will be noticed that all possible care was taken to prevent movement during ramming and that bolts were used in preference to spikes and catches, the bolt-holes being afterwards filled with cement.

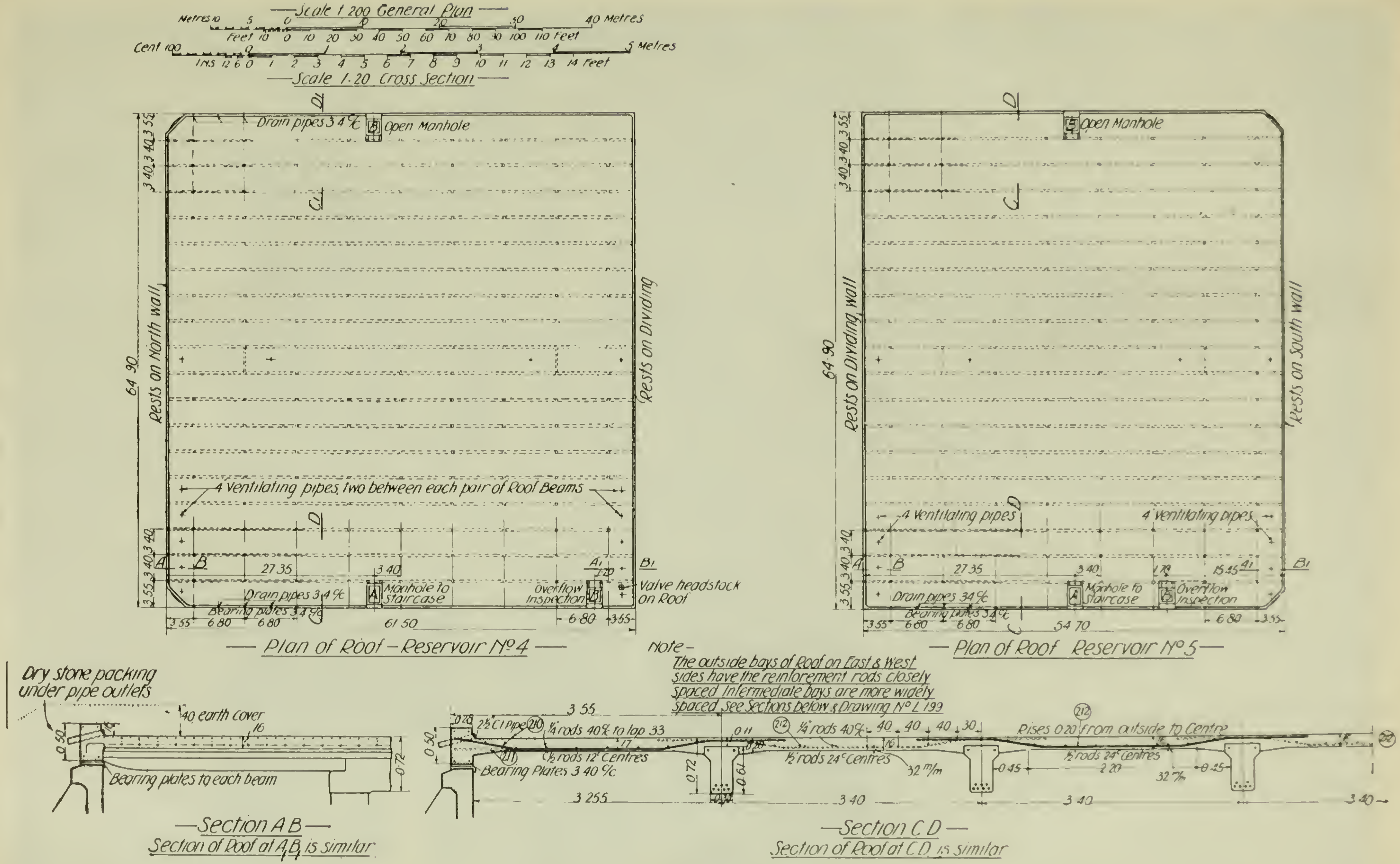

—Scale 1.200 General Plan—
Metres 10 5 0 10 20 30 40 Metres
Feet 10 0 10 20 30 40 50 60 70 80 90 100 110 Feet
Cent 100 0 1 2 3 4 5 Metres
Ins 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 Feet
—Scale 1.20 Cross Section—
Drain pipes 3 4 %
Open Manhole
Rests on North wall
Rests on Dividing
64 90
4 Ventilating pipes, two between each pair of Roof Beams
27 35
3 40
Drain pipes 3 4 %
Bearing plates 3 4 %
Manhole to Staircase
Overflow Inspection
Valve headstock on Roof
3 55 6 80 6 80 61 50 6 80 3 55
— Plan of Roof – Reservoir No 4 —
Rests on Dividing wall
Rests on South wall
4 Ventilating pipes
15 45
1 70
54 70
— Plan of Roof Reservoir No 5 —
Note –
The outside bays of Roof on East & West sides have the reinforcement rods closely spaced. Intermediate bays are more widely spaced. See Sections below & Drawing No L 199
Dry stone packing under pipe outlets
40 earth cover
16
0 50
0 72
Bearing plates to each beam
—Section A B—
Section of Roof at A1B1 is similar
3 55
2½ C I Pipe
¼ rods 40% to lap 33
½ rods 12 Centres
Bearing Plates 3 40 %
0 11
¼ rods 40%
½ rods 24 Centres
32 m/m
40 40 40 30
Rises 0 20 from outside to Centre
½ rods 24 Centres
2 20
0 45
0 25
3 255
3 40
3 40
3 40
—Section C D—
Section of Roof at C1D1 is similar

Fig. 10. Roof Plans.
Reinforced Concrete Reservoirs, Montevideo.

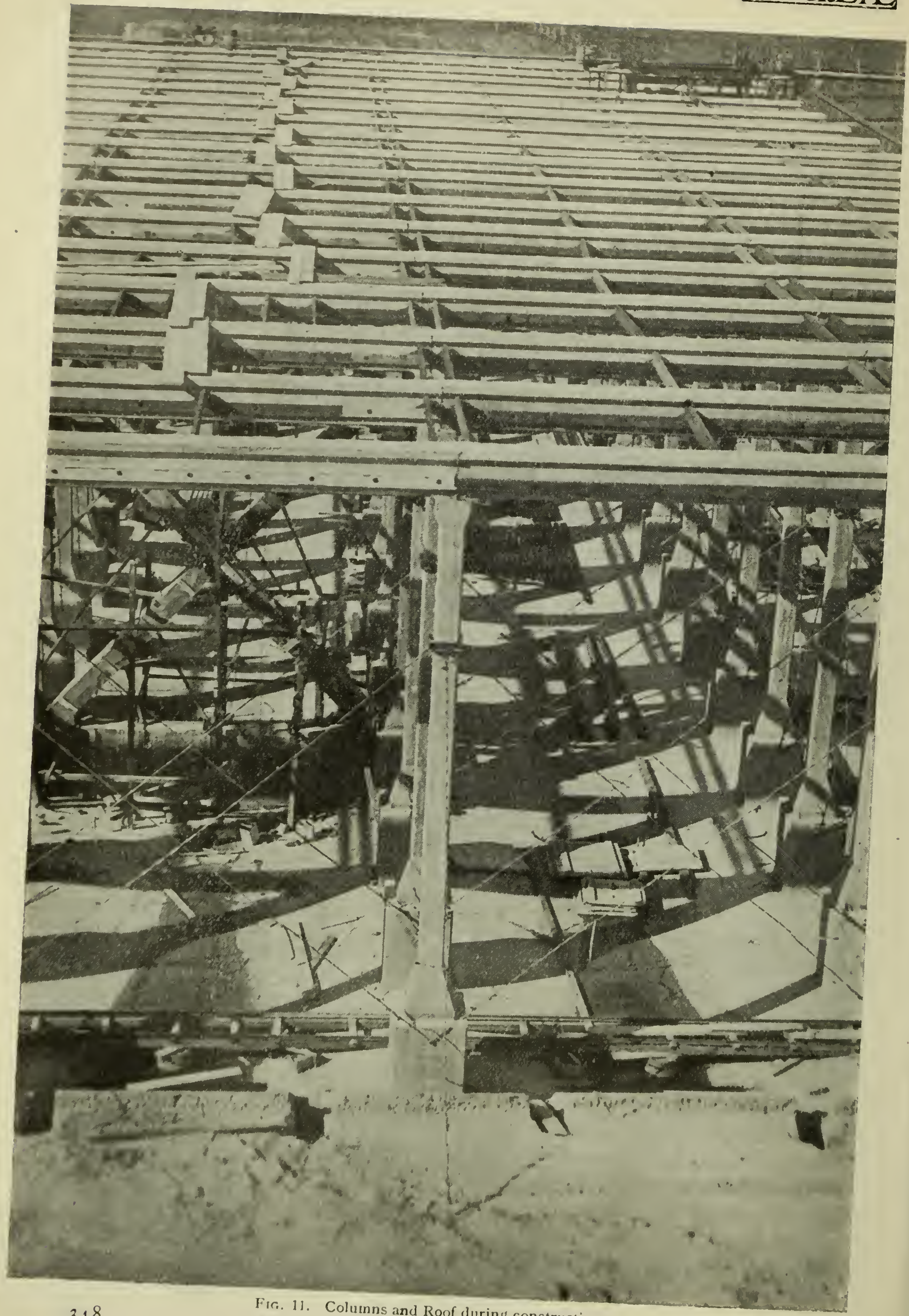


FIG. 11. Columns and Roof during construction.
REINFORCED CONCRETE RESERVOIRS, MONTEVIDEO.

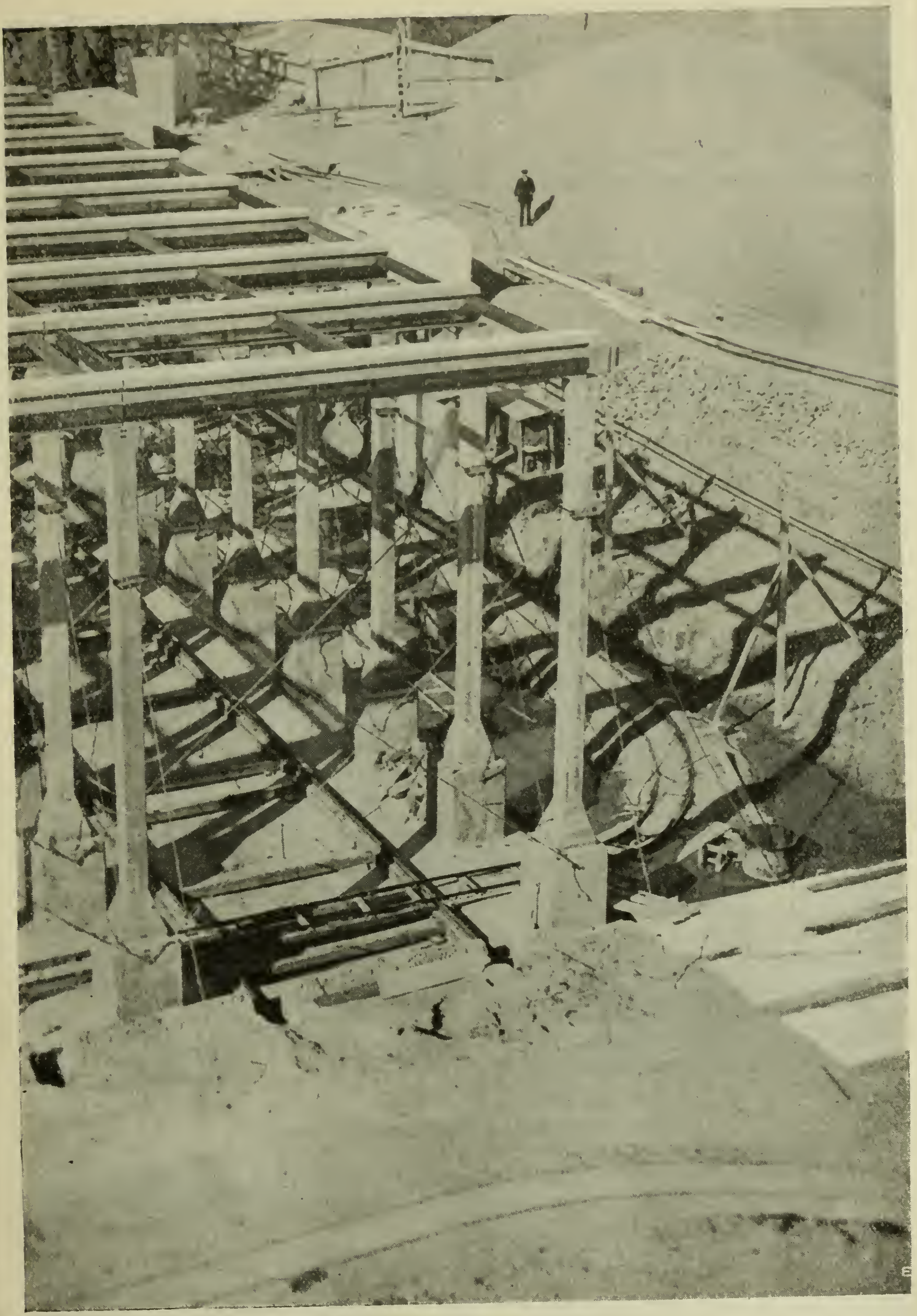


Fig. 12. Columns during Erection.
Reinforced Concrete Reservoirs, Montevideo.

Owing to the excessive heat means were taken to keep the concrete wet during the setting and to prevent the formation of cracks, and although tests at completion showed a few slight flaws the leaks totalled but 1½ cu. ft. per minute, and since treatment have been growing less and less, so that probably all leakage will soon be absent.

When due allowance is made for the various increases in the cost of construction, due to the war, it is found that under normal conditions the two reservoirs containing 13,000,000 gallons of water would haye cost £65,000 or £5 per 1,000 gallons. Contrasting this and those of other reservoirs constructed of reinforced concrete, it is found that the cost compares favourably.

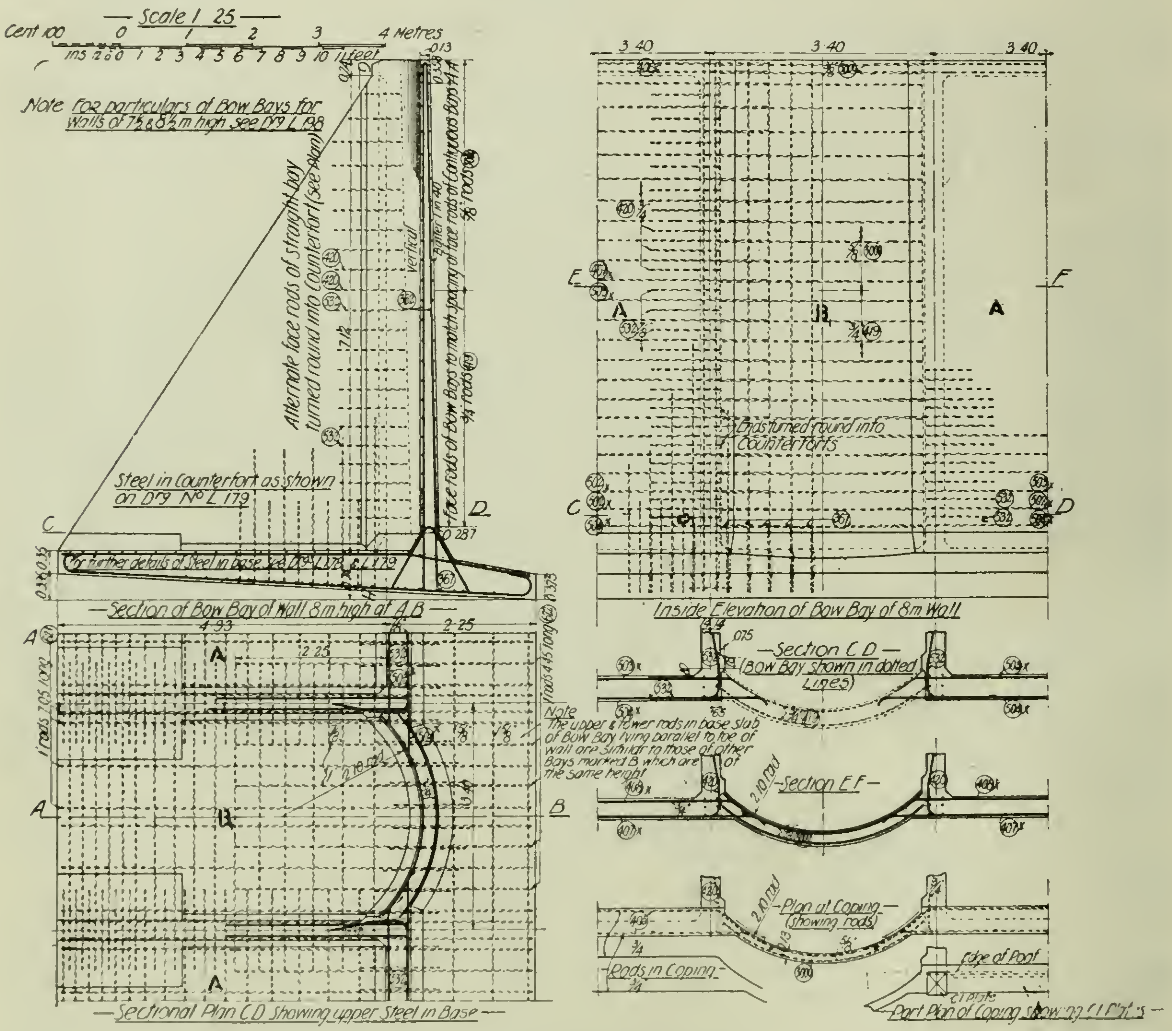

— Scale 1 25 —
Cent 100 0 1 2 3 4 Metres
ins 12 0 0 1 2 3 4 5 6 7 8 9 10 11 feet
Note For particulars of Bow Bays for Walls of 7½ & 8½ m high see D'g L 198
Alternate face rods of straight bay turned round into Counterfort (see plan)
vertical
Batter 1 in 40
Face rods of Bow Bays to match spacing of face rods of Contiguous Bays A A
Steel in Counterfort as shown on D'g No L 179
For further details of Steel in base see D'g L 178 & L 179
C
D
— Section of Bow Bay of Wall 8 m high at A B —
4·93
2·25
A
B
— Sectional Plan C D Showing upper Steel in Base —
3·40
E
F
Ends turned round into Counterforts
Inside Elevation of Bow Bay of 8 m Wall
— Section C D — (Bow Bay shown in dotted Lines)
Note The upper & lower rods in base slab of Bow Bay lying parallel to toe of wall are similar to those of other Bays marked B which are of the same height
— Section E F —
2·10 rad
— Plan at Coping — (showing rods)
Rods in Coping
Edge of Roof
C I Plate
Part Plan of Coping showing C I Plates —

FIG. 13. Detail of Segmental Bays in Outer Walls.
REINFORCED CONCRETE RESERVOIRS. MONTEVIDEO.

The whole of the work was designed by the Hon. R. C. Parsons, M.A., M.I.C.E., to whom we are indebted for the information given above and for the loan of the drawings and photographs reproduced.

No general contractor was employed, the works being carried out by labour directly employed and controlled by Mr. G. E. Arnold, who represented the Hon. R. C. Parsons on the works.

GOOD ROADS.

The following article, written by Mr. Edwin Tomlin, of Victoria, B.C., for the "Canadian Great War Veterans' Magazine" (British Columbia Branch) which we courteously acknowledge, will be read with interest by Engineers, Road Surveyors and members of public bodies who have to deal with the all-important subject of new roads in this country. Mr. Tomlin shows in a remarkably clear manner the wonderful progress which has been made in the construction of concrete roads in Canada and America during the last 10 years. The statistical information is worthy of close attention, especially at the present time when in many places experimental lengths of concrete roads are now being installed.—ED.

By EDWIN TOMLIN.

THERE is probably no subject of more general interest to-day to the people of British Columbia than good roads. Accustomed as we are in our beautiful Province to vast distances and the necessity for rapid means of transportation, good roads and plenty of them are a necessity. With the advent of the automobile at reasonable prices and the ability of the average man to find rest and recreation amid the beauties of mountain scenery and countryside, public interest has been directed to the roads of the Province. From a commercial standpoint also this is equally true. The universal demand to-day throughout Canada and America is for roads of a high standard of excellence. It is beginning to be clearly realised that makeshifts are a bad investment from every standpoint. Waste of effort and energy in travelling over bad roads is as serious a national loss as the yearly maintenance cost expended in a futile effort to maintain them, or the loss of time involved. The keynote of twentieth century ideals in nation building is conservation—conservation of natural resources, conservation of energy, conservation of time, and so on throughout all the departments of our national life.

As previously stated, public demand for to-day is for a high standard of excellence in the building of roads. The best only is the cheapest. This is true in all methods of public transportation. Badly constructed railroads with inefficient rolling stock cannot earn interest on capital expended, and the same is true of inefficient means of water transportation.

ROAD-BUILDING AN OLD SCIENCE.

Road building is a fairly old science. History records that it is primarily a military science, and we are forced to pay tribute to the thoroughness and method employed by the early road builders. Over 4,000 years ago a Babylonian Emperor employed 100,000 men for a period of ten years building a military road.

Herodotus, the historian, relates that the foundation stones of the road were ten feet in thickness. One cannot withhold admiration when reading such a statement. Imagine also 100,000 men in British Columbia employed constantly for the next ten years building good roads.

Continuing in chronological order the history of road making, we find the ancient Romans were very active indeed, and we can fairly award them the palm as being the first engineers to systematically construct and maintain public highways. During the height of the glory of the Roman Empire there were no less than twenty-nine great military roads radiating from the capital. These roads extended to every part of the vast empire, and are estimated to have had a total length of 50,000 miles.

We are told that the Roman construction was in general extremely massive. The Appian Way, extending from Rome to Capua, a distance of 142 Italian miles, and built over 2,200 years since, is recorded to have been in good repair 800 years after its completion.

The earth subgrade was very carefully prepared and four successive courses or layers placed thereon. These layers were as follows:—The statumen or foundation course, the rudus or second course, the nucleus or third course, and the pavimentum or wearing course. The top and bottom courses consisted in general of large flat stones, while the two intervening courses were built of smaller stone or other suitable material laid in lime mortar. With the fall of the Roman Empire these roads of course fell into decay, and to-day little more remains than a trace of these splendid achievements.

Napoleon can be justly called the founder of the French road system, which has broadened into the French Government institution known as the School of Roads and Bridges, which is one of the finest technical institutions in the world. These roads, which are of the macadam type, have received very severe usage during the late war, and were only kept in condition by the most incessant attention by repair gangs.

TRAFFIC PROBLEMS.

Dealing now with the problem as we find it in Canada and the United States, it may be stated that a complete revolution has taken place during the last ten years in the character of wheeled traffic and the loads carried. Previously the great percentage of traffic on American and Canadian roads was of the horse-drawn character, or ironbound, so to speak, and the ordinary macadam roads served very well indeed. This type of road depended for its permanence upon the binding power of the stone dust of which the surface is composed. Horses' hoofs and the iron tires of the wheels produced just enough fine material or dust to replace that which was blown away.

With the advent of the motor and propelled vehicle, however, entirely different conditions arose. With such vehicles, the power is applied entirely to the rear wheels, which exert a tremendous tearing and scouring action on the surface of the road, displacing this surface and producing no fine material to replace it.

MATERIALS.

Many binding materials have been tried with which it was hoped to hold the stones in the road more firmly in position, but either due to lack of strength or the fact that heavy rains and other climatic conditions disintegrated the top course of macadam, little or no success was attained. The advent of the concrete highway in Canada and the United States was a veritable godsend to road engineers, who were grappling with the ever-increasing problem of taking care of motor-propelled traffic successfully. For the last ten years the concrete road has been slowly forging its way to the front as the only permanent highway which will fulfil all expectations and demands made upon it. From a modest beginning in a general way in 1909 of 561,271 sq. yd. laid down, the volume has reached 25,000,000 sq. yd. annually, with a total in Canada and the United States to the end of last year of 117,605,464 sq. yd. This is a triumph for concrete. In order that a road may not disintegrate under the severest traffic a binding material must be used in its construction which will remain permanent in any temperature, and which will not be affected by climatic conditions. Furthermore, it must be a binding material which will hold the constituents of the road so firmly in place that they cannot be dislodged by either light or heavy horse drawn traffic or the swift-moving automobile or the heavy motor truck. Portland cement is the only binder known which will permanently answer these requirements and also preserve the perfect contour of the road. It is the only binder which not only does not weaken, but actually grows stronger with age. The concrete road offers to the public a pavement which will not become soft in summer or brittle in winter, a pavement which is not slippery in wet weather or dusty in dry, a pavement which will carry all kinds of traffic on a permanently even surface and with a minimum of tractive resistance.

STATE ROAD BONDS FOR PERMANENT ROADS.

After several years' experience struggling to maintain greatly travelled highways with a macadam surface, the States of the American Union have adopted a new policy of building permanent roads by means of State Road Bonds. It has been clearly recognised that the problem involved in taking care of modern motor-propelled traffic must be met and solved. The same statement is true as regards the Dominion of Canada, although we have given more attention to the roads of our cities than the character of our country highways. In solving this problem our cousins to the South have brought to bear the most expert engineering skill they could muster. As hundreds of millions of dollars have been raised for highway bonds, one can readily appreciate the necessity for wise discrimination in the selection of a type.

CONCRETE ROADS.

We find that the United States Bureau of Standards, the New York Bureau of Municipal Research, Harvard University, the New York State Highway Commission, the University of Illinois, the University of Wisconsin, Iowa State College, the Toronto Hamilton Highway Commission and other public bodies too numerous for specific mention have all taken a prominent part for several years past in preparing specifications for concrete roads and ensuring year by year the introduction of improvements in the methods employed. The present high standard of excellence now attained in concrete road building unfolds a story of persistent plodding effort on the part of some of the most brilliant engineering and scientific men of Canada and the United States. The specifications and methods for the construction of concrete roads to-day are as far advanced over those of ten years ago as is the modern automobile over the pioneer type. Rigid discrimination has been also exercised in the selection of proper aggregates, and we find the general standard of quality of Portland cement is much higher to-day than was the case ten years ago.

With a proper preparation of the subgrade and strict conformity to standard specifications, the modern concrete road is without an equal in durability and economical upkeep.

It will be of general interest to quote a few figures giving the volume of concrete road construction in Canada and the United States for the last decade.

	sq. yd.
Prior to 1909	799,390
Laid in 1909	561,271
,, 1910	1,313,499
,, 1911	2,069,445
,, 1912	5,295,447
,, 1913	9,596,286
,, 1914	14,815,034
,, 1915	16,936,137
,, 1916	24,218,955
,, 1917	25,000,000
,, 1918	17,000,000
Total	117,605,464

Concrete road construction in Canada and the United States was checked to some extent during 1918 by the late war, but during the present year everything points to the completion of a very large programme.

As some illustration of the popularity of concrete roads with our neighbours in the State of Washington, the following statistics as of date January 1st, 1918, are extremely interesting.

COUNTRY ROADS.

	Miles
Concrete Roads	331
Brick Roads	44
Asphaltic Roads	110
	485

In the Dominion of Canada there is one conspicuous example of the success and economy of a concrete road as compared with the macadam type. The highway in question is that extending from Toronto to Hamilton, a distance of 35 miles, which was laid with concrete for the entire stretch during the summer of 1915. On January 2nd, 1918, the following article appeared in *Contract Record,* published by the Hugh C. Maclean Publishing Co., regarding this highway :—

"The second year of maintenance on the Toronto Hamilton Concrete Highway closed October 31st, 1917, and the results only serve to emphasise the conclusions that could have been drawn last year. When the Commission is freed from the excessive cost of maintaining the short stretches of macadam at bridge approaches, the cost of repairs to the road surface will be almost negligible. On 312,100 sq. yd. of concrete (approximately 30 miles) the Commission spent in 1917 on tarring cracks and joints a total for labour and materials of $767.70. The result is extremely favourable when contrasted with a cost of $5,932.12 for repairs to 7,900 sq. yd. (approximately one quarter mile of macdam."

It is worth while to direct special attention to the fact stated in the above article that on 312,100 sq. yd. of concrete, the cost for maintenance was only $767.70, or approximately one quarter of a cent. per sq. yd. The traffic over this concrete road during the year 1917 was as follows :—

1914, previous to the highway being constructed, the highest daily average of traffic carried on that road was 520 vehicles, of which 262 were pleasure motor cars, 3 commercial motor cars, 199 horse-drawn pleasure vehicles, and 56 horse-drawn commercial vehicles. In 1916 there was a daily average of 3,254 vehicles recorded, 1,876 of which were pleasure motor cars, 142 commercial motor cars, 271 horse-drawn pleasure vehicles and 184 horse-drawn commercial vehicles. In 1917 the traffic was 3,841 vehicles daily, of which 3,065 were pleasure motor cars, 107 commercial motor cars, 148 horse-drawn pleasure vehicles and 41 horse-drawn commercial vehicles.

In the face of this tremendous increase in traffic the maintenance of the concrete has only been as stated, one quarter of a cent. per sq. yd., while for macadam on the same road the maintenance has been approximately 75 c. per sq. yd.

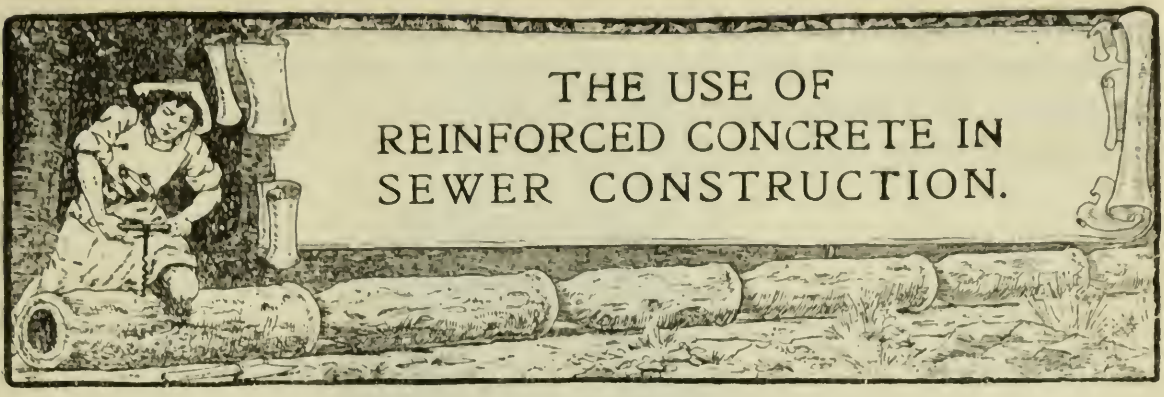
The building of permanent country highways has demonstrated a saving of time and an acquisition of income to the farmer and rancher which can no longer be lost sight of by governing bodies. It is clearly seen that the well-being and prosperity of the whole community depends to a very important degree upon the transportation facilities provided by our legislatures and municipal councils. A road that is fairly good for four months in the year, rutty and rough for another four months and like a bog or a ploughed field for the remaining period, does not make for prosperity from any standpoint. If a farmer has to provide two horses for hauling a load over a bad macadam road that would only need one horse on a concrete road, a general economy of time, effort and money is effected which is an asset to the State. The cost of transportation is reflected in the price of all commodities, and it is not necessary to carry the argument further to the mind of the average man without crystallising the conviction that the permanent road is the cheapest in the long run. We can struggle along with makeshifts, it is true, but it is a losing game. We cannot any longer blind our eyes to the fact that we have a new class of traffic to provide for, one that is used by the farmer, rancher, tradesman, business man and pleasure seeker, and in the concrete roads is found the ideal solution of the problem.

In our own Province of British Columbia the concrete road is, so to speak, a home production. There are modern up-to-date cement plants, manufacturing the highest grade of Portland cement. There are also numerous sand, gravel and crushed rock plants which can supply all the necessary aggregate for a concrete road.

British Columbia was never more in need of industries, population and capital than she is at the present time. This will be generally conceded. It does not require much argument to prove that we must patronise home industries if the Province is to become prosperous. Our cousins to the South of us have proved the truth of this principle.

CONCLUSION.

As a concluding word on this subject, is it not correct to state that with the period of reconstruction following the war upon us, with the task of assimilating our soldiers into civilian life again, we can enter upon no better work in British Columbia calculated to help and sustain our agricultural, industrial, economic and civilian life than a comprehensive programme of permanent road building, using the materials we have at our doors.



THE USE OF REINFORCED CONCRETE IN SEWER CONSTRUCTION.

By E. R. MATTHEWS, A.M.Inst.C.E., F.R.San.Inst., F.R.S.(Ed.), Chadwick Professor of Municipal Engineering in the University of London (Consulting Engineer).

The following article emphasises the value of reinforced concrete as a suitable material for sewer construction.—ED.

ENGINEERS are beginning to realise that there is no material more useful in sewer construction than reinforced concrete; it has taken British engineers several years to come to this conclusion, but it is the author's opinion that in the future the material will be largely used.

In the new sewerage system of San Francisco the sewers are for the most part of reinforced concrete, and the City Engineer informs the author that he has great faith in the use of this material for this purpose.

The sewers of Paris are also of reinforced concrete, and they have proved very successful.

It is the intention in this article to give a few typical designs of the types of sewers and manholes recommended for this purpose.

Fig. 1 illustrates a shallow oval manhole, the walls are built in 9 in. brickwork, and at this manhole there is a junction between a salt-glazed stoneware pipe sewer and a 2 ft. by 3 ft. egg-shaped sewer, built in reinforced concrete, the invert being lined with vitrified bricks; the reinforcement consisting of steel wire fabric, but almost any form of reinforcement is suitable.

Fig. 2 represents a manhole on a large circular reinforced concrete sewer. The sewer is built in reinforced concrete; it is 6 ft. internal diameter, and the reinforcement consists of ½ in. steel bars placed at 9 in. centres. The invert of the sewer is lined with vitrified bricks. In addition to the transverse reinforcement, longitudinal reinforcement is inserted, and this consists of ½ in. steel bars (square), placed at 6 in. centres. The width at base is 7 ft. 10 in., and the minimum thickness of concrete in the arch ring is 7 in., the thickness at the haunches being 11 in.

Timbering for such a sewer in bad ground :—

Fig. 3 shows timbering suitable for a trench up to a depth of 25 ft. in bad ground.

Fig. 4 shows the method adopted by the author to strengthen a concrete-tube sewer, say, 30 in. in diameter, in a deep trench in bad ground. A good foundation of 6 to 1 plain concrete is first put in ; upon this the tubes are laid and haunched up, a hood of reinforced concrete being turned over the pipes. It is always advisable to render this over with 1 to 1 cement rendering, 1 in. in thickness.

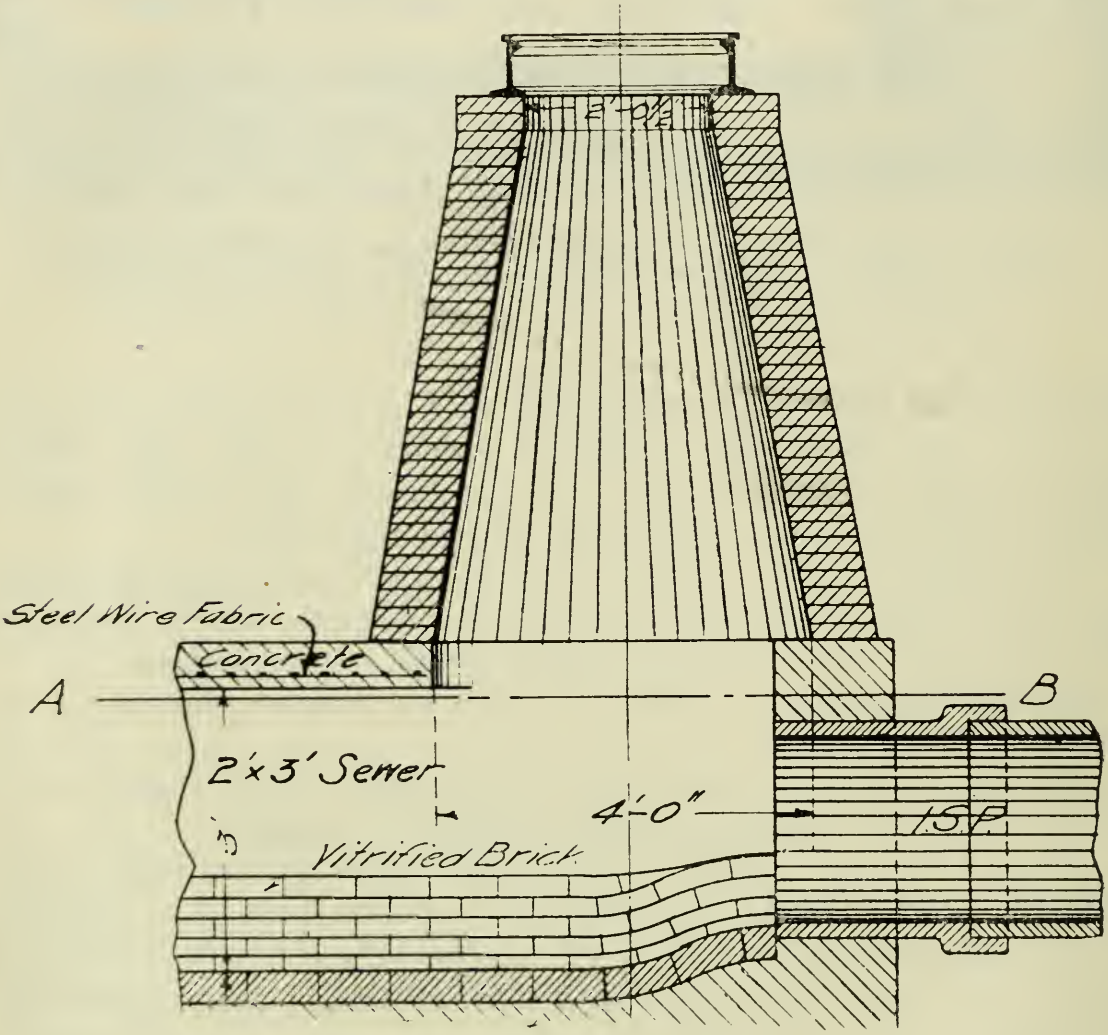


Fig. 1. Junction of Stoneware Pipe and Egg-Shaped Sewer.

It is seldom that a flat-topped sewer, as shown in *Fig.* 5, is constructed in this country,' but in America such types are quite common. In the construction of sewers of this class it is only necessary to reinforce the roof slab. Almost any form of reinforcement is suitable ; the vitrified bricks forming the invert in *Fig.* 5 should have been radiated. All reinforcement should have at least 1½ in. covering of concrete ; the thickness of the roof slab need not exceed 6 in.

Fig. 6 illustrates a 10 ft. taper connection in a reinforced concrete sewer. This sewer is similar in section to that shown in *Fig.* 2, but tapers from 6 ft. diameter to 6 ft. 6 in. The reinforcement consists chiefly of ½ in. square steel bars, but round bars of the same sectional area would have done equally as well, or expanded metal.

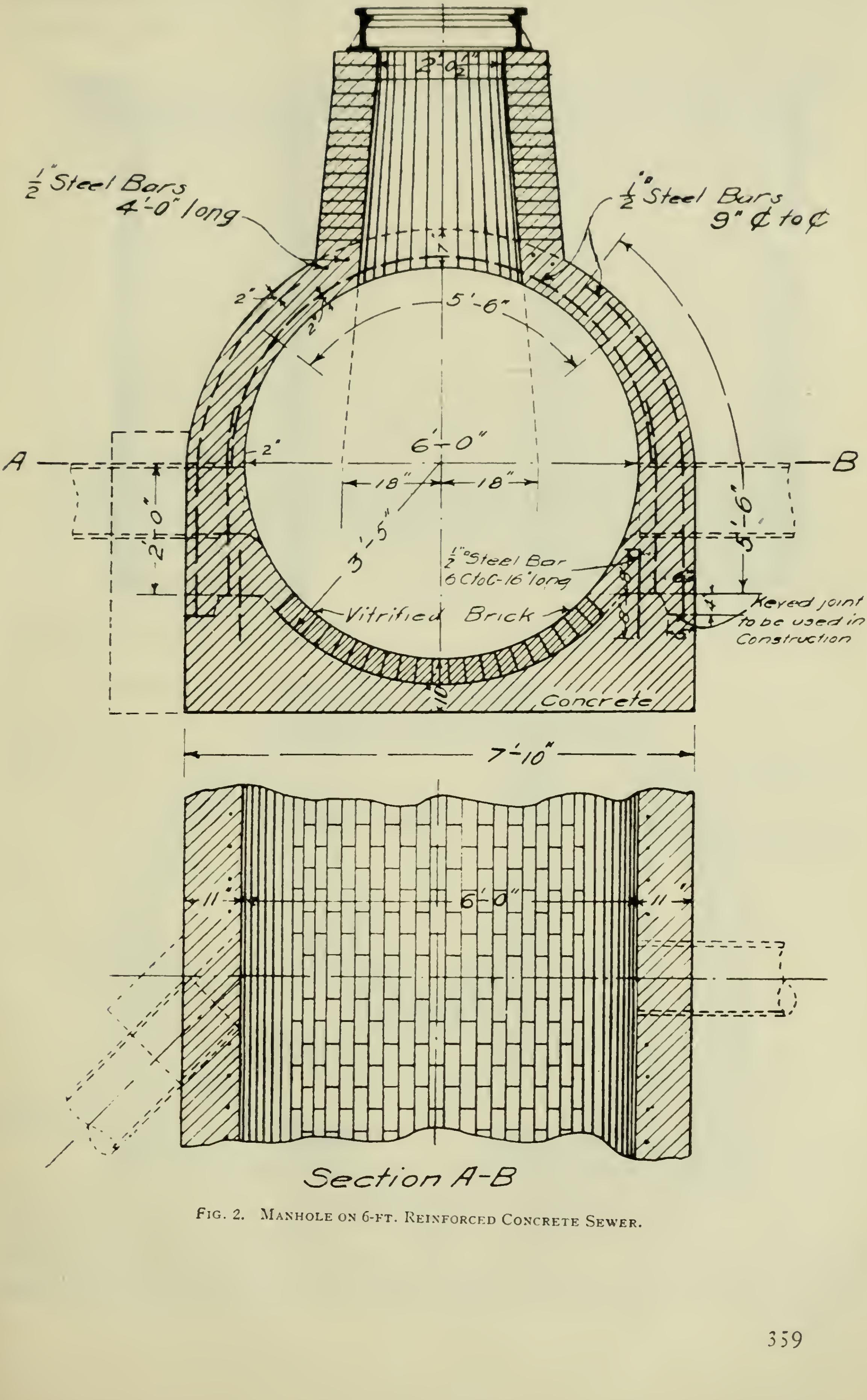


FIG. 2. MANHOLE ON 6-FT. REINFORCED CONCRETE SEWER.

In *Fig. 7* we have a junction manhole in plain concrete for a 2 ft. 6 in. by 3 ft. 9 in. reinforced concrete sewer on the curve. This is an American design, and it should be pointed out that in Great Britain circular manholes are not looked upon with favour; the bricked invert in this country is always constructed in radiated bricks, and not as shown in *Fig. 7*.

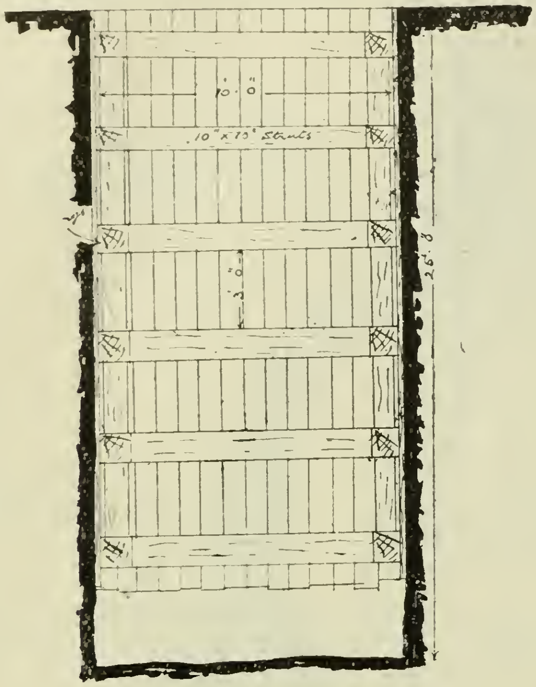


FIG. 3. TIMBERING FOR SEWER IN BAD GROUND.

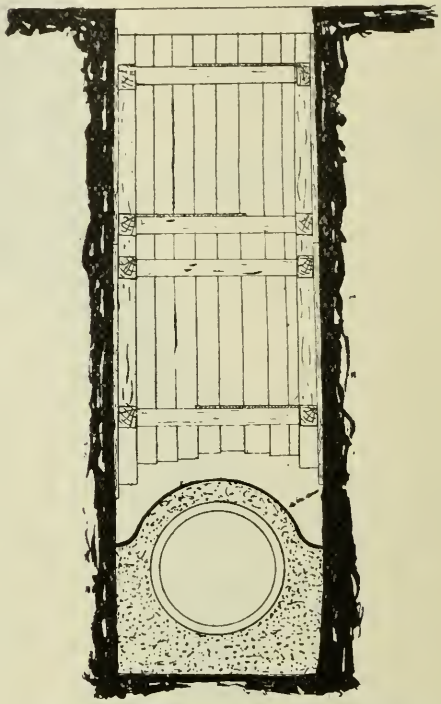


FIG. 4. CONCRETE TUBE SEWER WITH REINFORCED CONCRETE HOOD IN BAD GROUND.

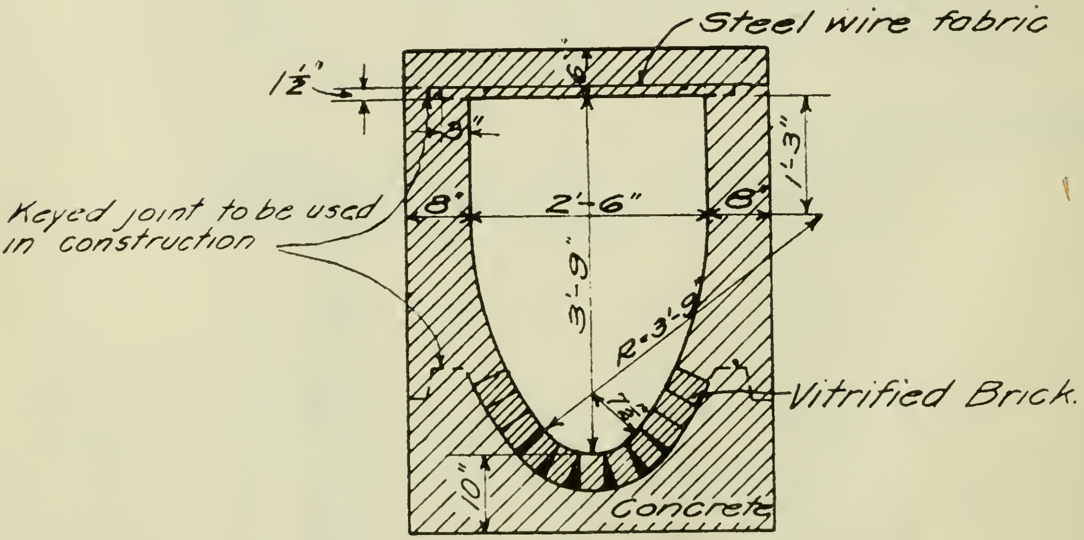


FIG. 5. EGG-SHAPED SEWER WITH FLAT TOP.

Fig. 8 shows a method recommended by the author for carrying an iron-pipe sewer across a stream or canal. The supports on either side are of reinforced concrete; in the one case a short retaining wall, strengthened by buttresses, supports the two 18 in by 12 in. reinforced concrete beams upon which the pipes rest, and in the other case (see *Fig.* 8) the buttresses are omitted but the base of the wall strengthened. The two reinforced

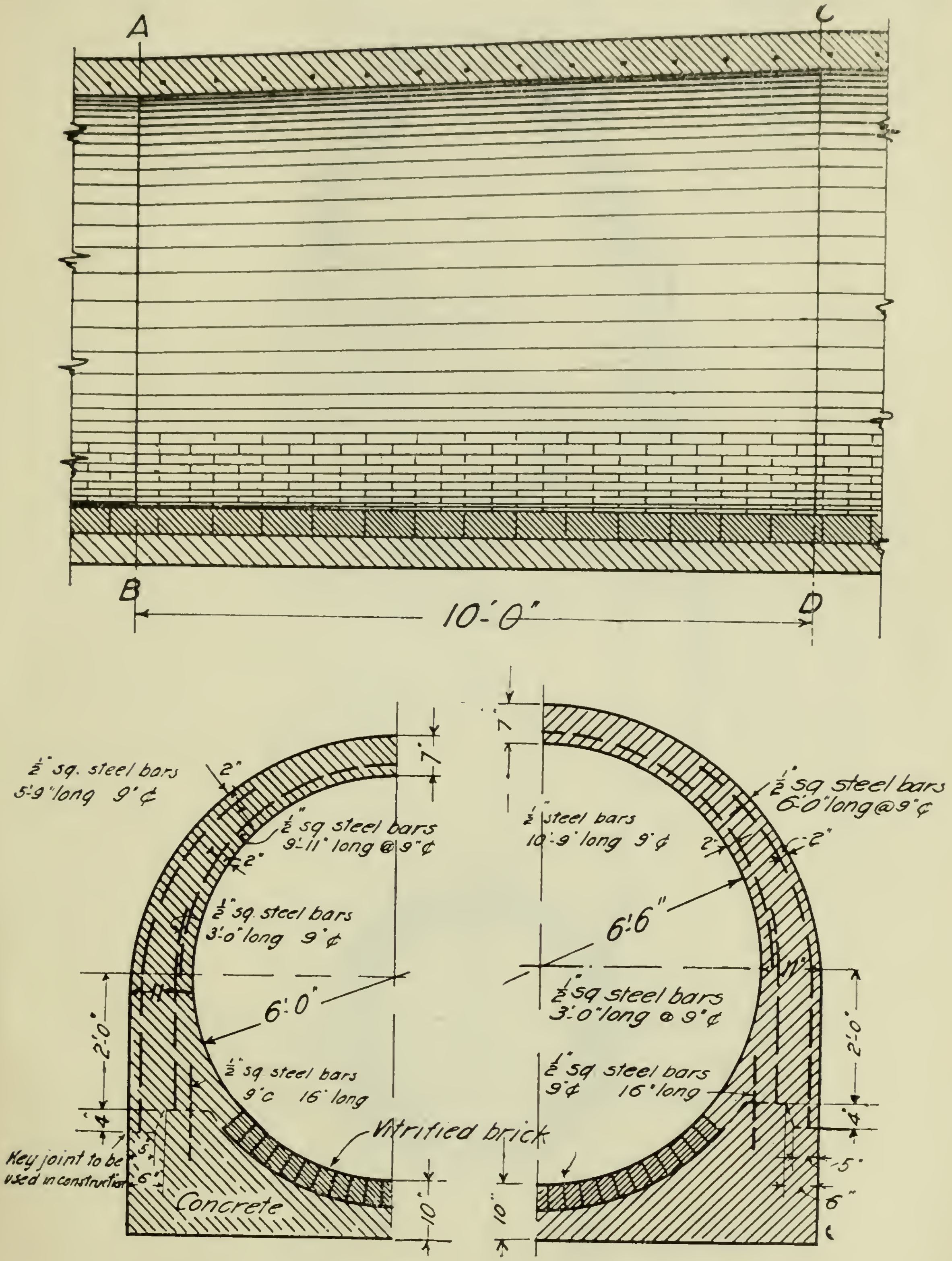
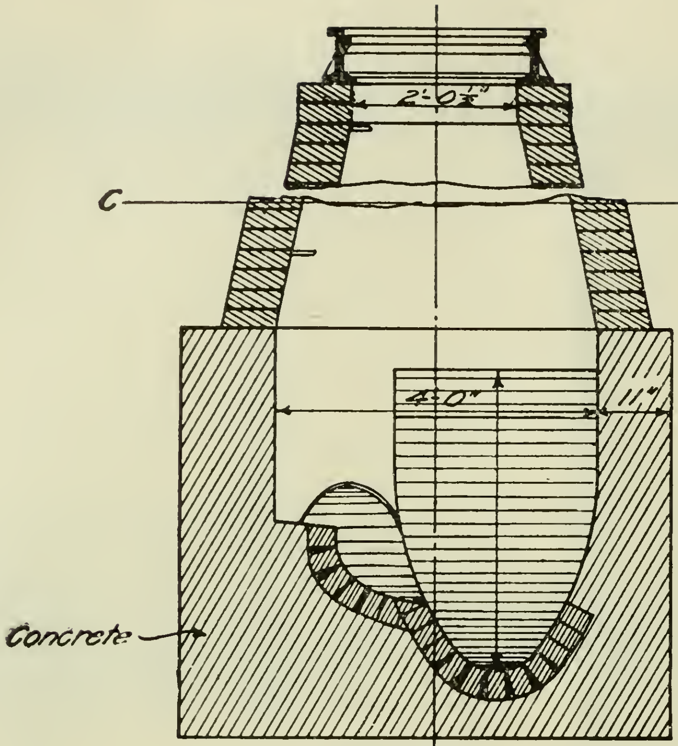
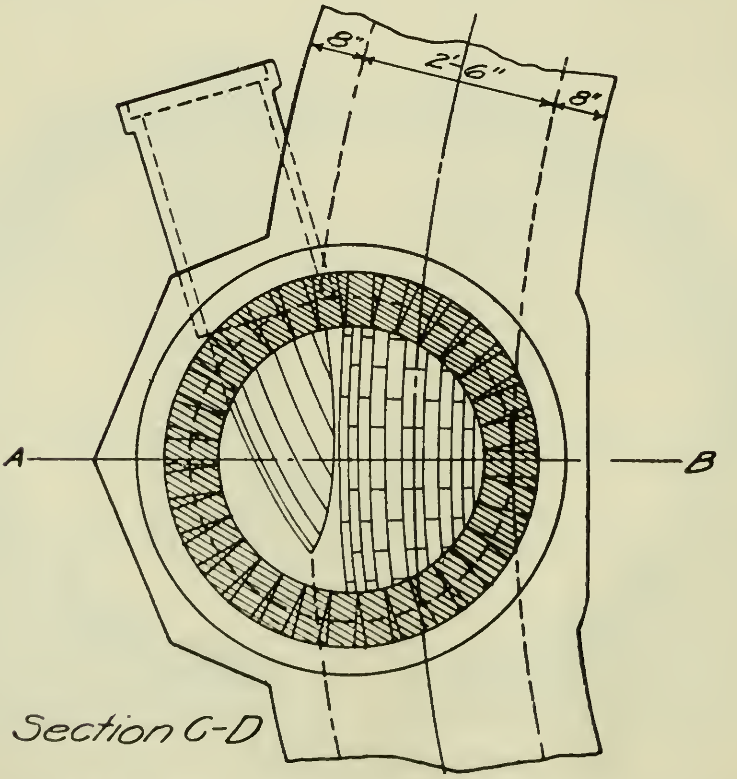

A
C
B
D
10'-0"
½" sq. steel bars 5'-9" long 9" ¢
2"
½" sq steel bars 9'-11" long @ 9" ¢
2"
½" sq. steel bars 3'-0" long 9" ¢
6'-0"
11"
2'-0"
4"
½" sq steel bars 9" c 16" long
Vitrified brick
Key joint to be used in construction
5"
6"
Concrete
10"
7"
7"
½" steel bars 10'-9" long 9" ¢
½" sq steel bars 6'-0" long @ 9" ¢
2"
2"
6'6"
½" sq steel bars 3'-0" long @ 9" ¢
11"
½" sq steel bars 9" ¢ 16" long
2'-0"
4"
5"
6"
10"

FIG. 6. 10-FT. TAPER CONNECTION IN REINFORCED CONCRETE SEWER.

concrete beams would be about 6 in. apart. The span is 24 ft. and the dimensions of the reinforced concrete supports are shown.



Section A-B.



Section C-D

Fig. 7. Junction Manhole for 2 ft. 6 in. by 3 ft. 9 in. Reinforced Concrete Sewer.

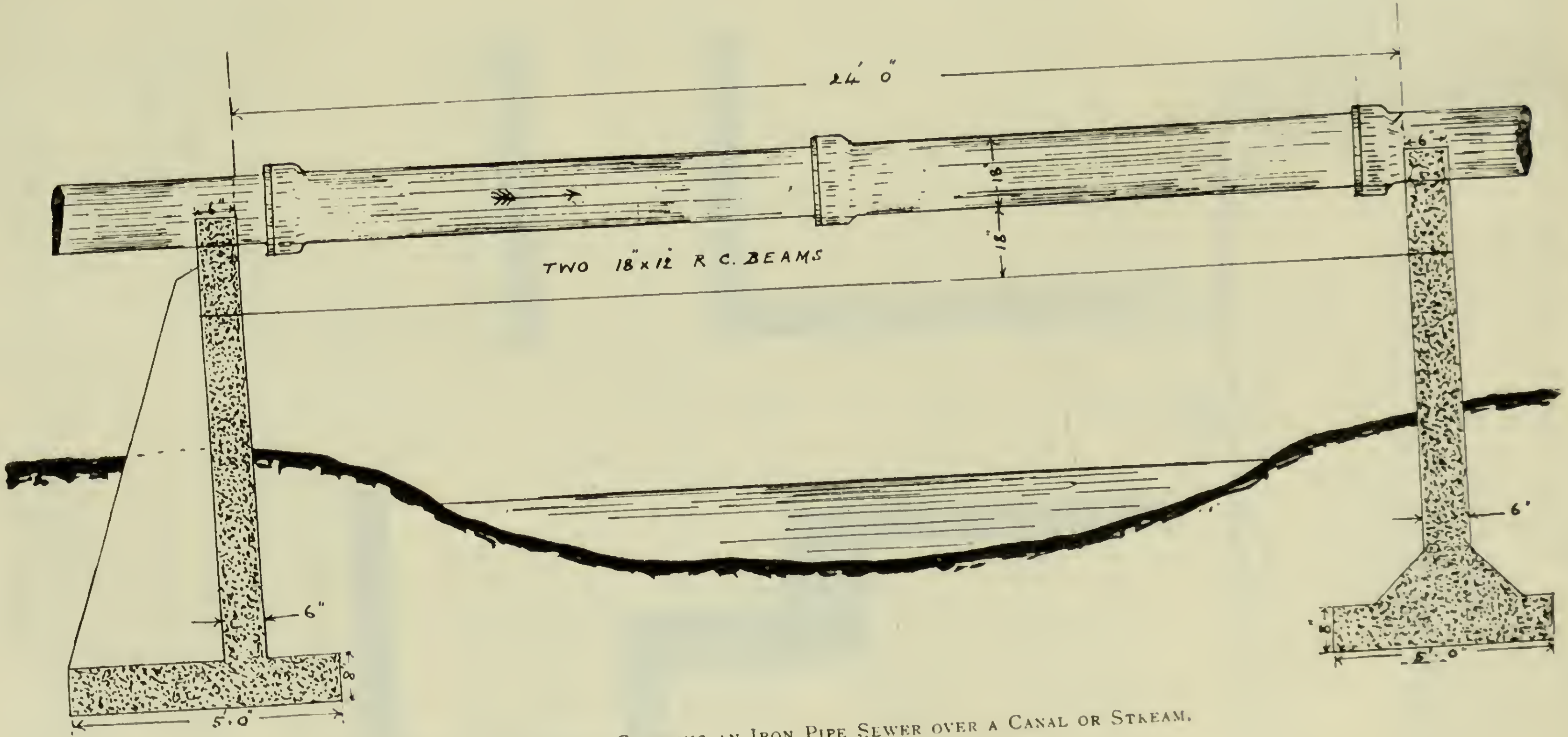


FIG. 8. METHOD OF CARRYING AN IRON PIPE SEWER OVER A CANAL OR STREAM.

Fig. 9 represents a manhole at the junction of two reinforced concrete circular sewers. This is a type the author frequently recommends. The diagram shows a reinforced concrete sewer 5 ft. in diameter joining a 7 ft. reinforced concrete sewer. The tumbling bay, which breaks the velocity, is stepped, and formed of plain concrete ; the whole structure may be in reinforced concrete, in which case the walls would be 6 in. in thickness only, but the author has shown them to be built in 14-in. brickwork, as this facilitates the building in of the step-irons. The reinforced concrete slab supporting the manhole cover need not be more than 4 in. in thickness. Almost any form of steel reinforcement is suitable.

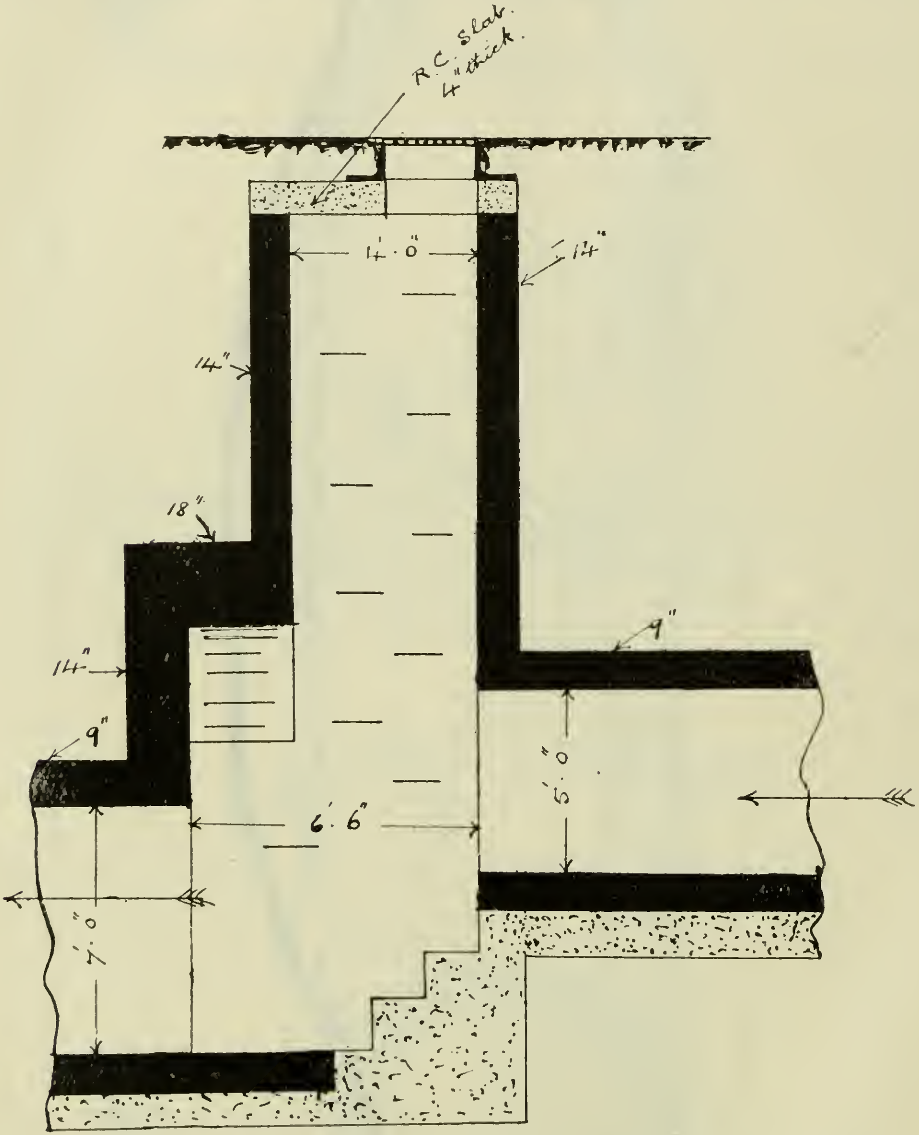


Fig. 9. Manhole at Junction of Two Large Reinforced Concrete Sewers.

The author has endeavoured in this short article to show that it is quite possible to construct sewers, regardless of their size or shape (above 2 ft. diameter), in reinforced concrete, and he estimates that by doing so a saving of 25 per cent. can be effected.

A NOTE ON REINFORCED CONCRETE TEE BEAMS.

By THOMAS PETTY.

In reinforced concrete slabs the ratio of the depth or thickness to the superficial dimensions is seldom of primary importance, and the thickness is determined directly by calculations based upon the allowable working stresses for the materials involved.

The conditions as regards beams, whether of rectangular or tee section, are, however, not quite so simple.

In these the relative proportions of breadth, depth and span are affected by considerations of economy of material ; attainment of correct architectural proportion ; provision of adequate shear area and lateral stability ; the headroom available ; and the minimum proportions enjoined by the regulations of the governing body within whose area of jurisdiction the structure is to be erected.

It is, therefore, usually convenient to tentatively fix upon such approximate dimensions of cross section as are generally suitable in the circumstances of a particular case ; and thereafter by calculation to determine the amount of tensile reinforcement necessary, and verify the adequacy of the concrete to meet the compressive stresses. Cases may arise, however, where for various reasons a more direct method is preferable.

In such cases a slight modification of the ordinary treatment employed for slabs will suffice where beams of rectangular section or tee beams having the neutral axis within the slab are concerned ; while in the case of tee beams having the neutral axis external to the slab, and, the dimensions of the flange being fixed, it is sought to determine by direct calculation the depth of rib and amount of tensile reinforcement necessary to meet certain definite conditions as to stress allowance, one of the following methods may be found of service :—

Let B = bending moment of external loads and forces at section in pounds-inches.
R_c = resistance moment of the internal stresses in the beam in terms of the permissible compressive working stress.
t = permissible tensile working stress in tensile reinforcement, in lbs. per sq. in.
c = permissible compressive working stress at the extreme edge of the concrete in compression, in lbs. per sq. in.
E_c = elastic modulus of concrete in compression.
E_s = elastic modulus of steel in tension.
m = modular ratio $= \dfrac{E_s}{E_c}$
b = breadth of flange in inches.
d = effective depth of the beam in inches, *i.e.*, the distance from the compressed edge of the constructional concrete to the common centre of gravity of the tensile reinforcement.
d_s = total depth of flange in inches.
A = area of tensile reinforcement in square inches.
a = arm of the resistance moment, in inches.

n=distance of the neutral axis from the compressed edge of the constructional concrete of the beam in inches.

$n_1 = \frac{n}{d}$ = neutral axis ratio. $\therefore n_1 d = n$.

n_2=reciprocal of neutral axis ratio, $= \frac{1}{n.} = \frac{d}{n} \therefore n_2 n = d$, and $\frac{d}{n_2} = n_1$

METHOD I.—Making all the customary assumptions, we have:—

$$tn = mc\ (d-n) \tag{1}$$

$$\text{from whence } n_2 = 1 + \frac{t}{mc.}$$

By law as to position of neutral axis, and neglecting compression in the rib, we have:—

$$bd_s\left(n - \frac{d_s}{2}\right) = Am\ \ (d-n)$$

$$\text{whence } A = \frac{bd_s\ (2n - d_s)}{2m\ (d-n)} \tag{2}$$

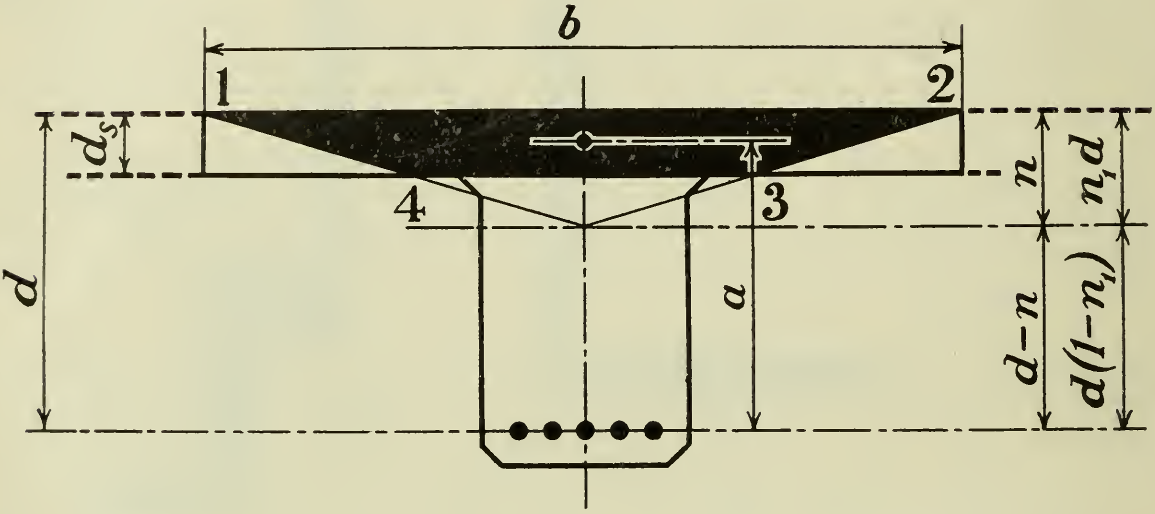


Fig. 1.

The equivalent uniform resistance area of concrete 1. 2, 3, 4 (see *Fig.* 1) will be:—

$$bd_s\left(\frac{2n-d_s}{2n}\right) \tag{3}$$

$$= bd_s - \frac{bd_s^2}{2n}$$

$$\text{and } a = d - \frac{3nd_s - 2d_s^2}{6n - 3d_s} \tag{4}$$

Then

$$R_c = c\left(bd_s - \frac{bd_s^2}{2n}\right)\left(d - \frac{3nd_s - 2d_s^2}{6n - 3d_s}\right)$$

$$= \frac{cbd_s}{6n}\left[3d(2n-d_s) - d_s(3n - 2d_s)\right] \tag{5}$$

Since $B = R_c$ we may re-write expression (5) as follows, replacing R_c by B and d by $n_2 n$ thus:—

$$B = \frac{cbd_s}{6n}\left[3n_2 n(2n - d_s) - d_s(3n - 2d_s)\right]$$

from which $n_2 n + \frac{d_s^2}{3n} = \frac{B}{cbd_s} + \frac{d_s}{2}(n_2 + 1)$

$$\text{Let } \frac{B}{cbd_s} + \frac{d_s}{2}(n_2 + 1) = y \tag{6}$$

Then $n_2 n + \frac{d_s^2}{3n} = y$

multiply by n and divide by n_2, giving:—

$$n^2-\frac{y}{n_2n}=-\frac{d_s^2}{3n_2}$$

Complete the square by adding $\left(\frac{y}{2n_2}\right)^2$ thus:—

$$n^2-\frac{y}{n_2}n+\left(\frac{y}{2n_2}\right)^2=\left(\frac{y}{2n_2}\right)^2-\frac{d_s^2}{3n_2}$$

giving $$n=\frac{\sqrt{9y^2-12n_2d_s^2+3y}}{6n_2}$$

whence $$d=\sqrt{\frac{9y^2-12n_2d_s^2+3y}{6}} \qquad (7)$$

Example on METHOD I.

In a tee beam composed of concrete having proportions of 1 : 2 : 4 by volume

b $=48$ inches
$d_s=4$ inches
$B=1{,}500{,}000$ pounds inches.

Required: the depth of rib and amount of tensile reinforcement necessary to comply with the L.C.C. Regulations.

Under the L.C.C. Regulations $t=16{,}000$, $c=600$, $m=15$ and $mc=9{,}000$, giving to n_2 a value of $\frac{25}{9}=2{\cdot}\dot{7}=$ say $2{\cdot}778$.

From (6) $$\begin{aligned} y&=\frac{B}{cbd_s}+\frac{d_s}{2}(n_2+1)\\ &=\frac{1{,}500{,}000}{600\times48\times4}+\frac{4}{2}(2{\cdot}778+1)\\ &=20{\cdot}577.\end{aligned}$$

From (7) $$\begin{aligned} d&=\sqrt{\frac{9y^2-12n_2d^2_s+3y}{6}}\\ &=\sqrt{\frac{9\times20{\cdot}577^2-12\times2{\cdot}778\times4^2+3\times20{\cdot}577}{6}}\\ &=19{\cdot}829 \text{ inches.}\end{aligned}$$

$$n=\frac{d}{n_2}=\frac{19{\cdot}829}{2{\cdot}778}=7{\cdot}138$$

From (2) $$\begin{aligned} A&=\frac{bd_s\,(2n-d_s)}{2m\,(d-n)}\\ &=\frac{48\times4\,(14{\cdot}276-4)}{2\times15\,(19{\cdot}829-7{\cdot}138)}\\ &=5{\cdot}18 \text{ sq. ins.}\end{aligned}$$

METHOD II.

From (1) $$n_1=\frac{1}{1+\frac{t}{mc}}$$

and from (2) $$A=\frac{bd_s\,(2n_1d-d_s)}{2md\,(1-n_1)} \qquad (8)$$

The equivalent uniform resistance area of concrete may be written from (3) as:—

$$bd_s\left(\frac{2n_1d-d_s}{2n_1d}\right)$$

From (4) $$a=d-\frac{3n_1d_sd-2d_s^2}{6n_1d-3d_s}$$

Hence $$\begin{aligned} R_c&=cbd_s\left(\frac{2n_1d-d_s}{2n_1d}\right)\left(d-\frac{3n_1d_sd-2d_s^2}{6n_1d-3d_s}\right)\\ &=\frac{cbd_s}{6n_1d}\left[6n_1d^2-(3+3n_1)\,d_sd+2d_s^2\right] \qquad (9)\end{aligned}$$

Replacing R_c by B and arranging in the most suitable form for actual calculation of beams, we may write (9) thus:—

$$B = \frac{b d_s}{6 n_1 d}\left[6 c n_1 d^2 - (3+3n_1)\, c\, d_s d + 2 c\, d_s^2\right] \qquad (10)$$

With this method it is at this point convenient to substitute numerical values for c and n_1.

Under the L C.C. Regulations

$$n_1 = \frac{1}{1+\frac{16{,}000}{9{,}000}} = 0{\cdot}36,$$

while c varies from 600 to 750, according to the proportions of the concrete by volume.

The following table will facilitate the casting of expression (10) into the proper form for use with any particular value of c.

TABLE I.

Proportions of concrete by volume.	Cement	1	1·2	1·5	2
	Sand	2	2	2	2
	Coarse material ...	4	4	4	4
c, Lbs. per sq. in. ...	... ...	600	650	700	750
m	... ...	15·00	13·85	12·86	12·00
n_1	... ...	0·36	0·36	0·36	0·36
$6\ n_1$	... ...	2·16	2·16	2·16	2·16
$6\ c\ n_1$...	... ...	1,296	1,404	1,512	1,620
$(3+3\ n_1)\ c$	... ...	2,448	2,652	2,856	3,060
$2\ c$	... ...	1,200	1,300	1,400	1,500

Example on METHOD II.

Taking the same case as before, and inserting the values for concrete having proportions by volume of 1 : 2 : 4 from the table, we may write expression (10) thus:—

$$\frac{b d_s}{2{\cdot}16 d}(1{,}296 d^2 - 2{,}448 d_s d + 1{,}200 d_s^2) = B$$

in which form it may be used for the solution of all beams composed of concrete of these proportions.

In the example

$b = 48$ inches
$d_s = 4$ inches
$B = 1{,}500{,}000$ pounds inches.

Then $$\frac{48 \times 4}{2{\cdot}16 d}(1{,}296 d^2 - 2{,}448 \times 4 d + 1{,}200 \times 4^2) = 1{,}500{,}000$$

from whence $$1{,}296 d^2 - 9{,}792 d + 19{,}200 = 16{,}875 d$$

and $$1{,}296 d^2 - 26{,}667 d + 19{,}200 = 0$$

which by cancellation gives:—

$$d^2 - 20{\cdot}576 d + 14{\cdot}814 = 0.$$

Employing the usual formula for the solution of a quadratic equation of this type, we have:—

$$d = \frac{20{\cdot}576 \pm \sqrt{20{\cdot}576^2 - 4 \times 14{\cdot}814}}{2}$$

from which, taking the larger root

$$d = \frac{20{\cdot}576 + 19{\cdot}081}{2}$$
$$= 19{\cdot}829 \text{ inches.}$$

From (8) $$A = \frac{b d_s (2 n_1 d - d_s)}{2 m d (1 - n_1)}$$
$$= \frac{48 \times 4 (2 \times 0{\cdot}36 \times 19{\cdot}829 - 4)}{2 \times 30 \times 19{\cdot}829 (1 - 0{\cdot}36)}$$
$$= 5{\cdot}18 \text{ sq. in.}$$

"CONCRETE SHIPBUILDING"

It is our intention to discontinue this series as a special supplement, and to incorporate it in each issue of the magazine.—ED.

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER IV. Design—(*concluded*).

PONTOONS.

Pontoons may be regarded as vessels which are usually located at one place, and even when moved they do not usually travel very far. They are generally designed to carry heavy loads and often serve the purpose of a landing stage or of an extension of the wharf. They must therefore be built very strongly, yet little or no attention need be paid to the rate at which they can be transported.

In the pontoons (*Figs.* 147-148) on the Panama Canal the only bracing of the hull consists of two 3 in. bulkheads extending from bow to stern. The reinforcement is composed of ½ in. square deformed bars placed on 9 in. centres lengthwise and 12 in. centres crosswise, covered with ½ in. No. 12 wire netting, followed by a ½ in. coat of cement mortar, applied direct to the reinforcement.

The pontoon built for Sydney Harbour is divided into 44 compartments by means of bulkheads 4 in. thick, which stiffen the structure and also support the deck. This pontoon contains 342 cub. yds. of concrete and 43 tons of steel.

A concrete pontoon on the Manchester Ship Canal is divided into one large watertight compartment for coal and boiler, and four smaller compartments approachable only from hatches on deck. Thus, in the event of a collision, the efficiency of the bulkheads does not depend on doors being closed.

The framework of the pontoon consists of beams, ribs, columns, and struts in monolithic connection and further connected by the longitudinal and transverse bulkheads, the bottom sides and ends of the hull, and the main decking slab.

The compartment devoted to the boiler contains a powerful beam supporting the scoping floor of the coal bunkers and three transverse cradles carrying the boiler.

FLOATING DOCKS.

It is only natural that floating docks should be constructed of concrete, but so far only one is known. This (*Fig.* 149) is at Christiania and was built by the Fougner Company, of Moss, Norway. It is 80 ft. long by 38 ft. wide and 20 ft. high, with a

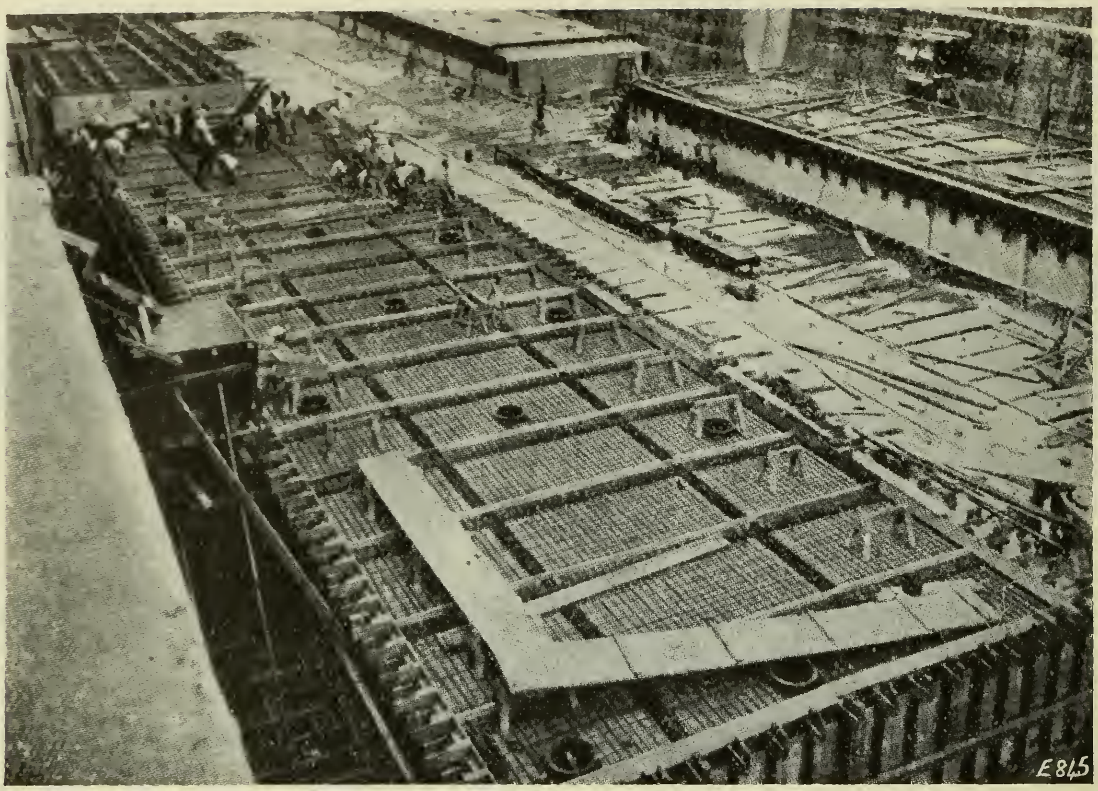


Fig. 147. General View of Reinforcement in place for constructing deck of Concrete Pontoons on Panama Canal.

sill 4 ft. 6 in. thick, side walls 6 ft. 6in. at the bottom, and will accommodate a vessel 75 ft. long and 25 ft. beam. This dock consists of nine watertight compartments and can lift a load of 100 tons out of the water in an hour.

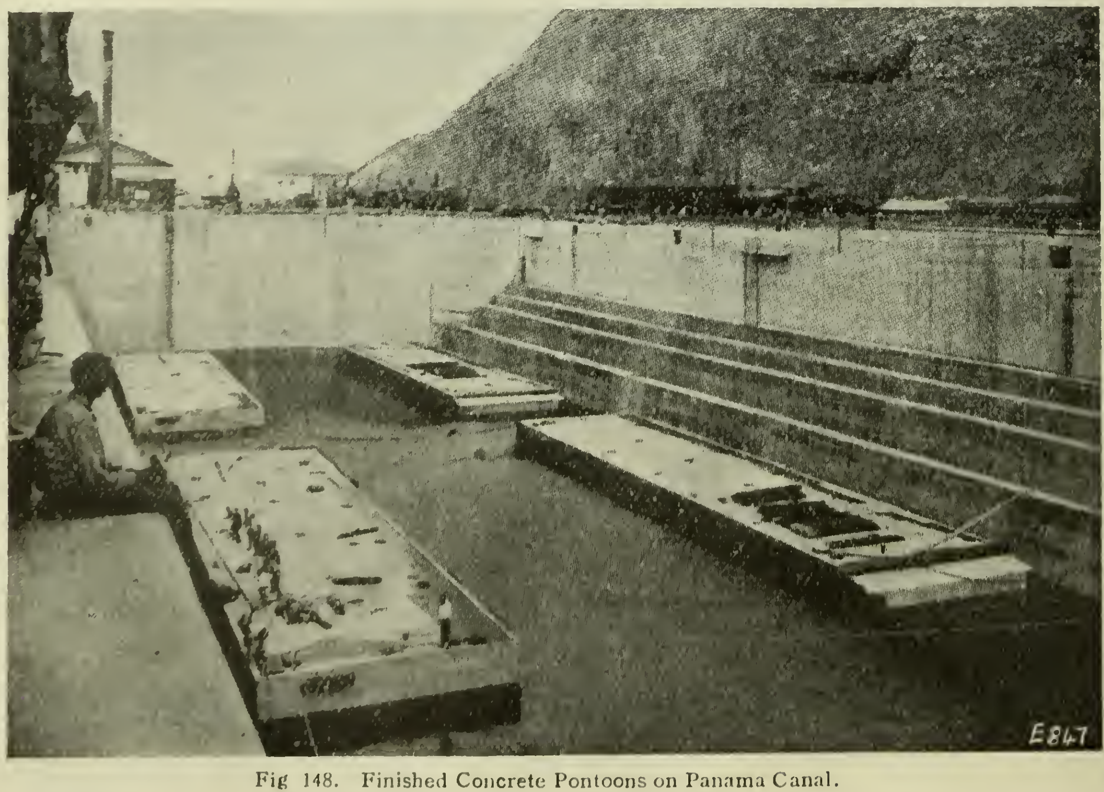


Fig 148. Finished Concrete Pontoons on Panama Canal.

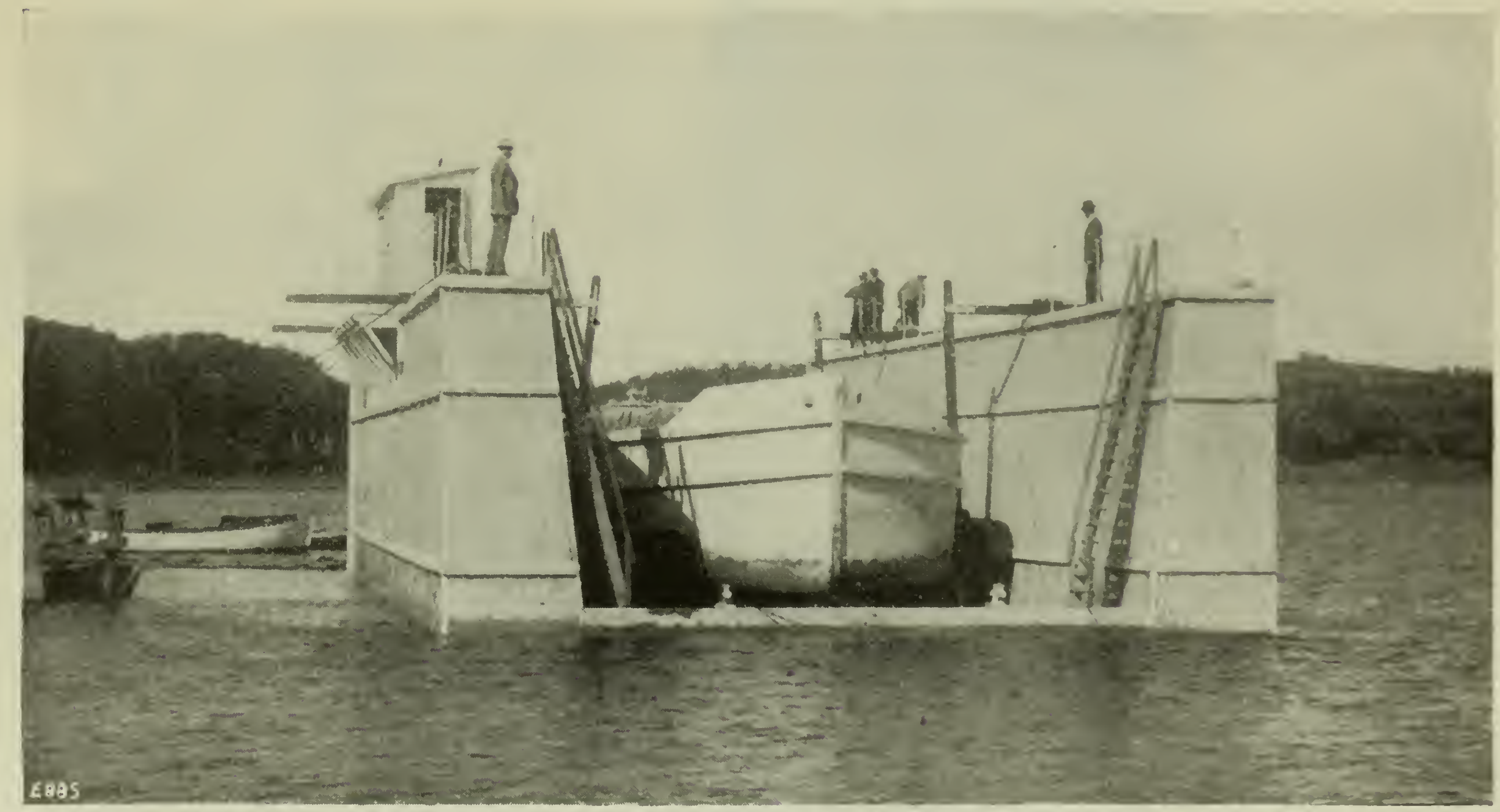


Fig. 149. **Floating Dock, built of Fougner Steel-Concrete, with Lighter inside.**

CAISSONS.

As previously explained, it is often convenient to construct caissons on slipways in a similar manner to a concrete vessel, launch them and tow them to the required site and then to fill them with sand or other similar materials so as to sink them. The reinforcement of these caissons is similar to that of a concrete vessel (*Figs.* 150-155).

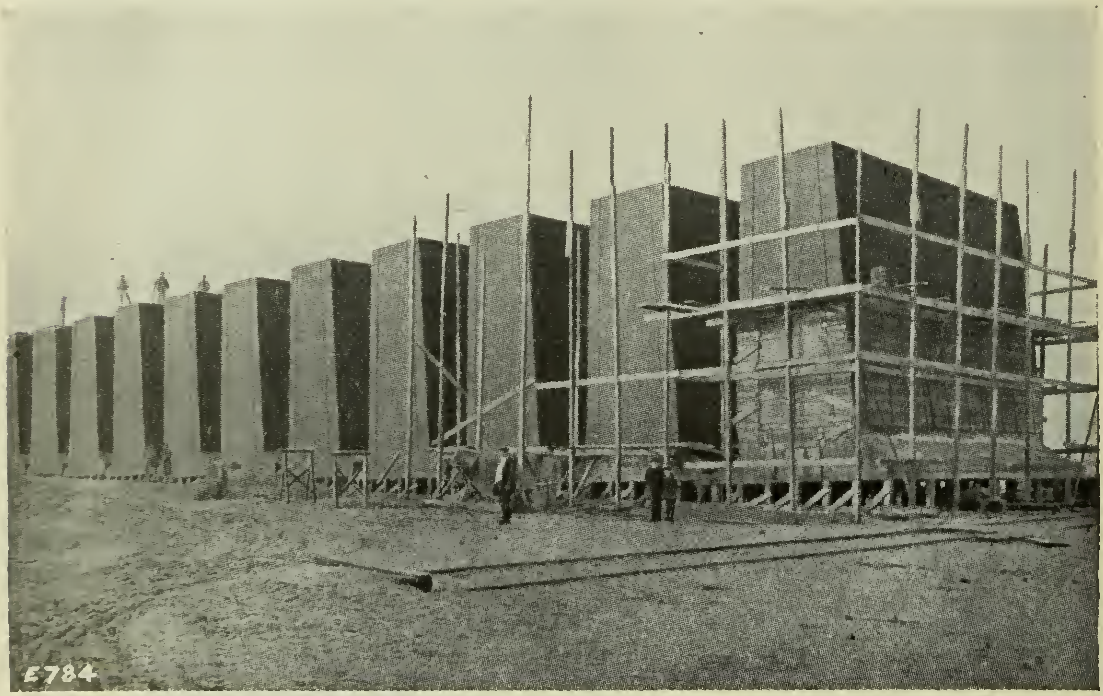


Fig. 150. Reinforced Concrete Caissons prior to launching.

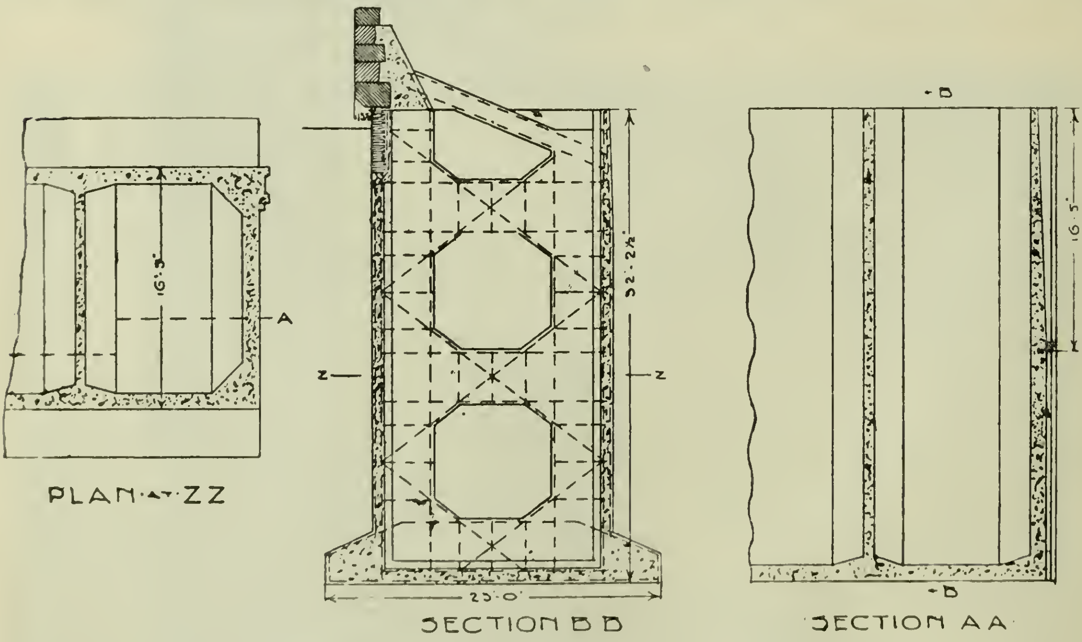


Fig. 151. Reinforced Concrete Caissons, Copenhagen.

The ones at Copenhagen are stiffened internally by means of cross beams 4 ft. 3 in. deep, spaced on 10 ft. 9 in. centres. In a caisson forming the lower part of the beacon at Alexandria (*Figs.* 154-156), erected in 1911, a sole 40 ft. by 37 ft. and 8 in. thick is reinforced by transverse flat bars and a longitudinal joist, and joined to the caisson

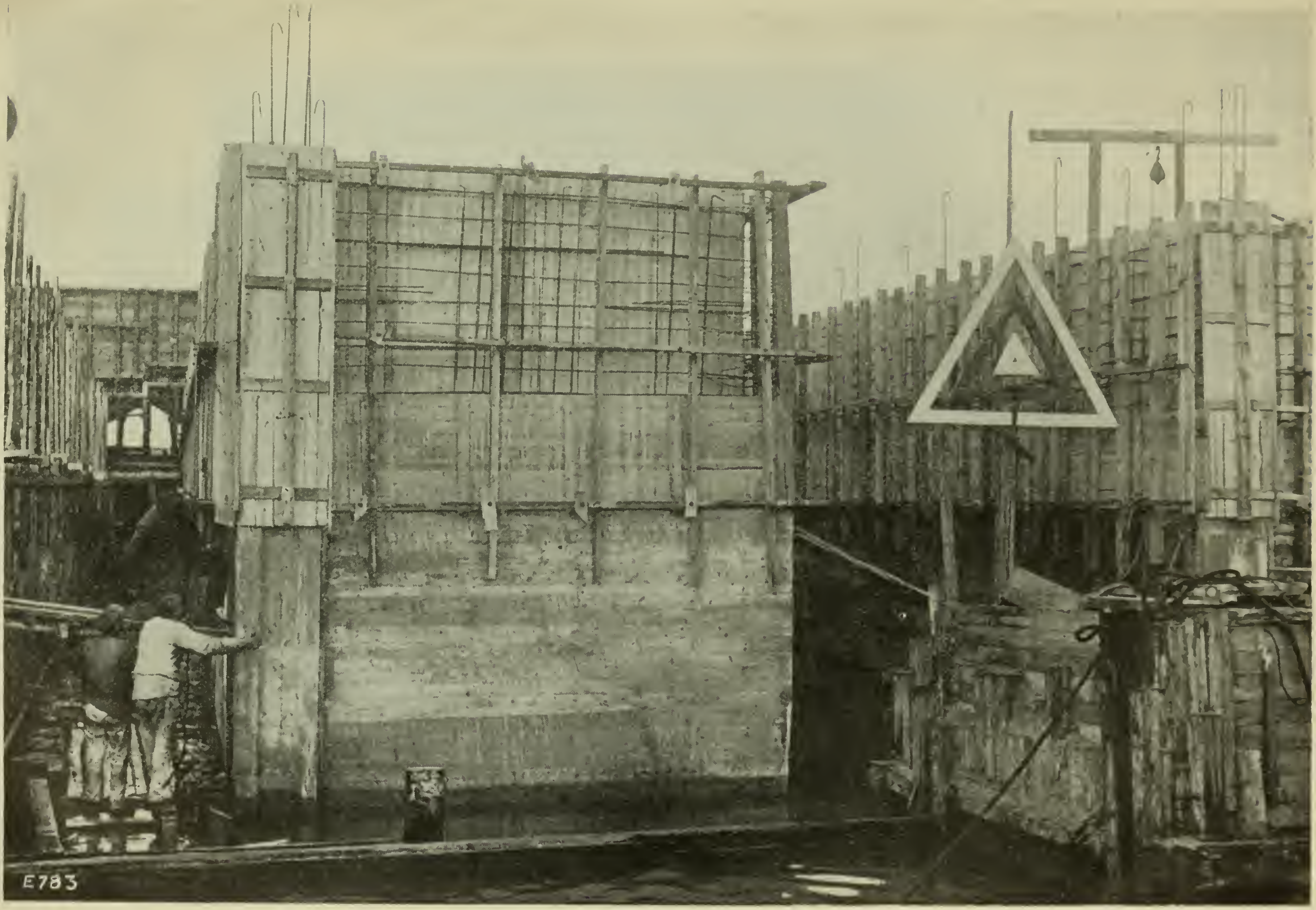


Fig. 152. View showing construction in Dry Dock.

by 18 triangular buttresses. The walls of the caissons are 6 in. thick. There is a central column, 12 in. square, with four radiating groups of eight horizontal beams, each 8 in. square, and four oblique beams for stiffening the caissons during immersion. The caisson was built on a slipway and launched as shown in *Fig.* 156, towed $2\frac{1}{2}$ miles, and then filled with water by pumping and so sunk.

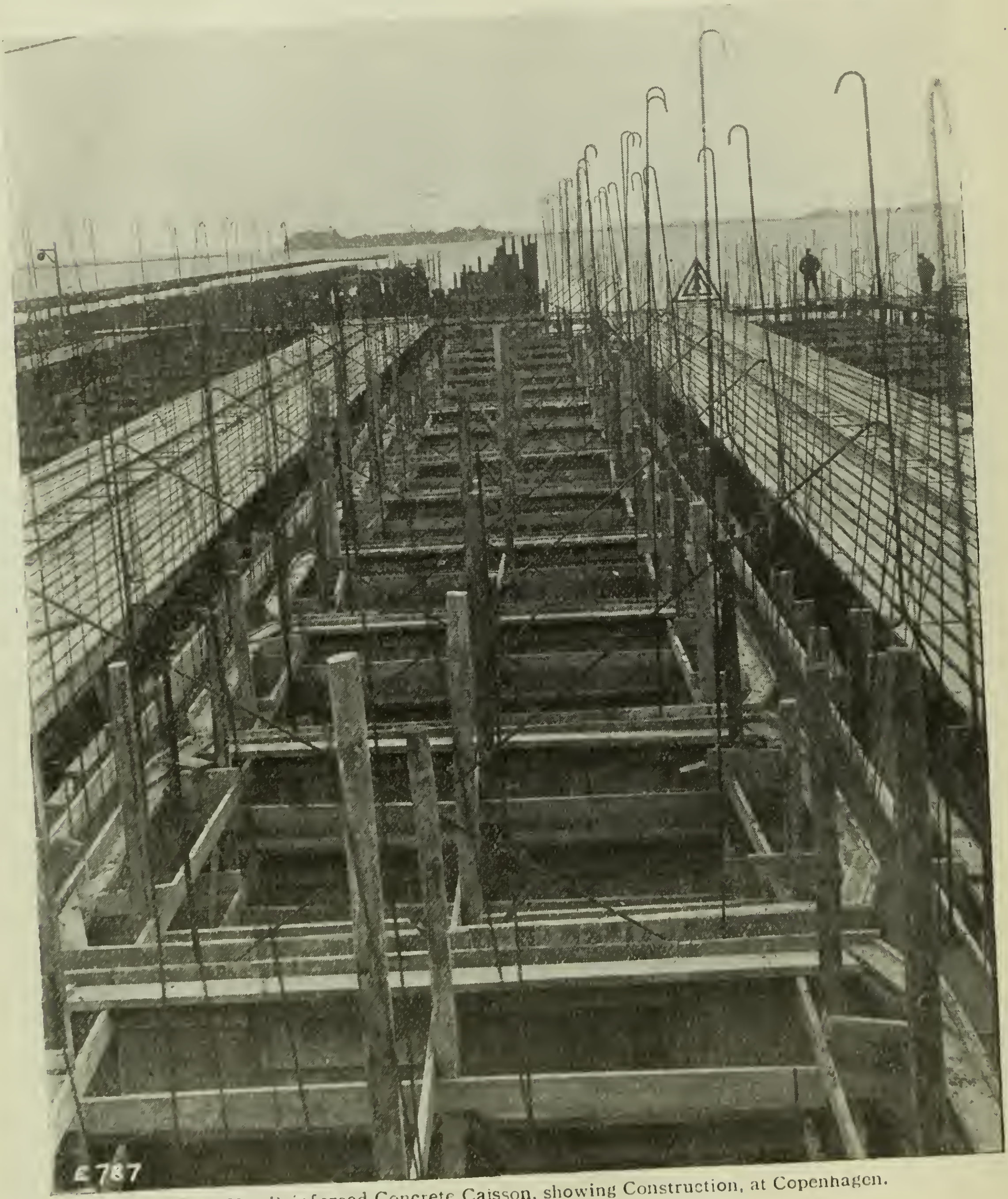


Fig. 153. Reinforced Concrete Caisson, showing Construction, at Copenhagen.

FLOATING BUOYS.

A description of concrete ships would scarcely be complete without some mention of the concrete buoys erected at Kingston, Jamaica, in 1913. These are cylindrical structures (*Fig.* 157) with a concave bottom. The sides are reinforced by Hy-rib steel mesh, the ribs of which are placed horizontally. The reinforcing-bars at the bottom are bent upwards so as to be carried inside this mesh. The top of each buoy is a solid slab, with the reinforcing bars bent downwards over the sides. The sides are plastered inside and out to a total thickness of 3 in. A small pumping pipe is fitted so as to remove any water which may have entered the buoy before the concrete hardens, though this is scarcely necessary. The concrete is waterproofed. These buoys cost less than half those made of steel previously used and avoid the serious upkeep charges for the latter.

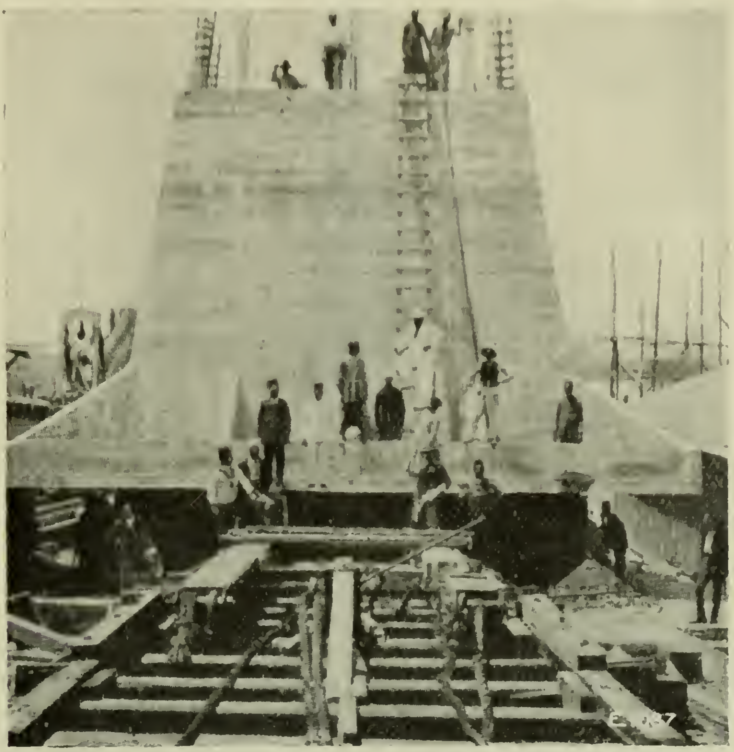


Fig. 154. First part of Caisson ready on slipway.

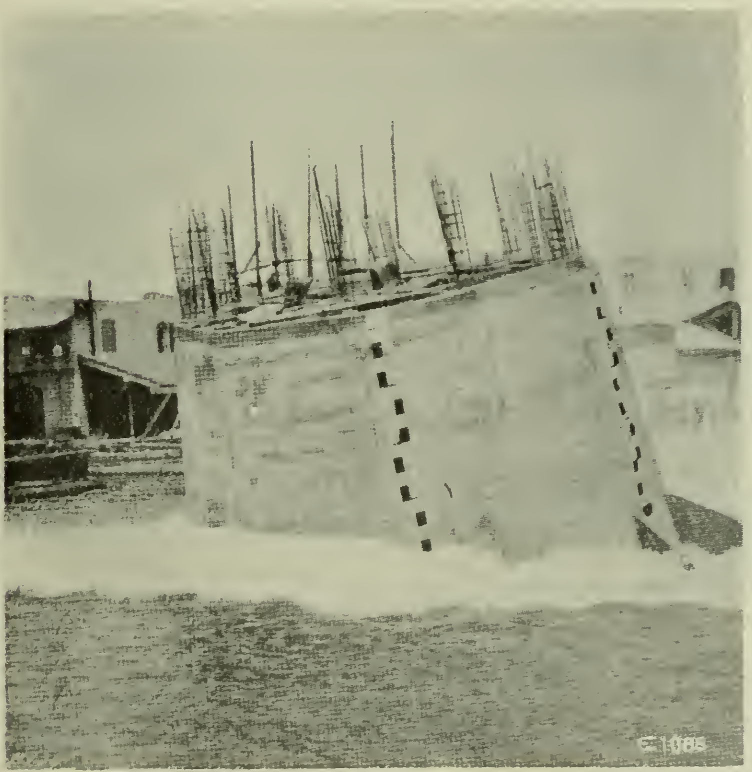


Fig. 155. First part of Caisson at the moment of launching.

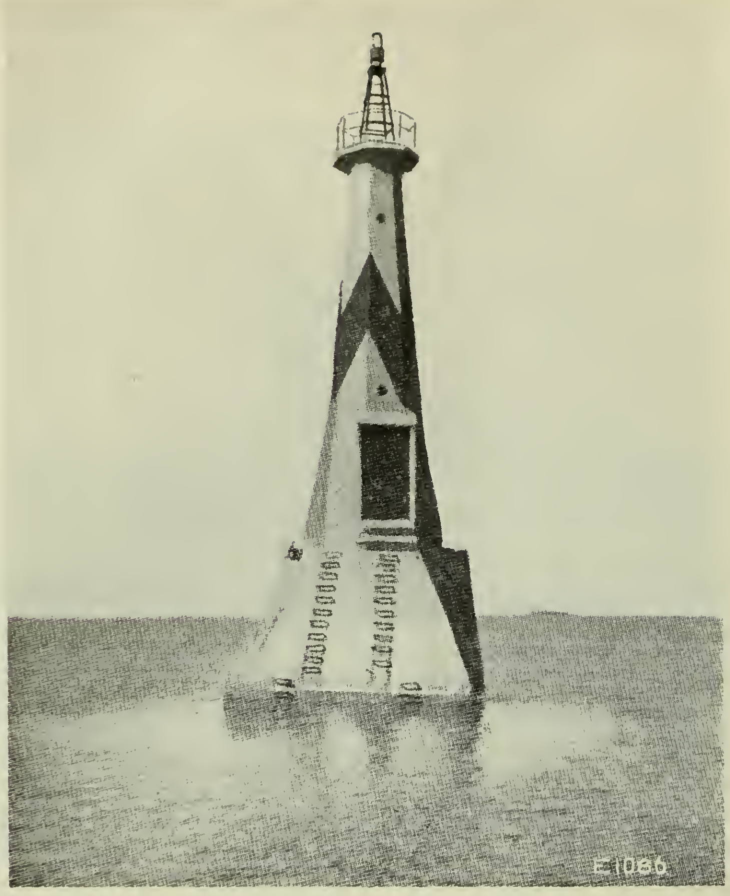


Fig. 157. View of finished Beacon at Alexandria.

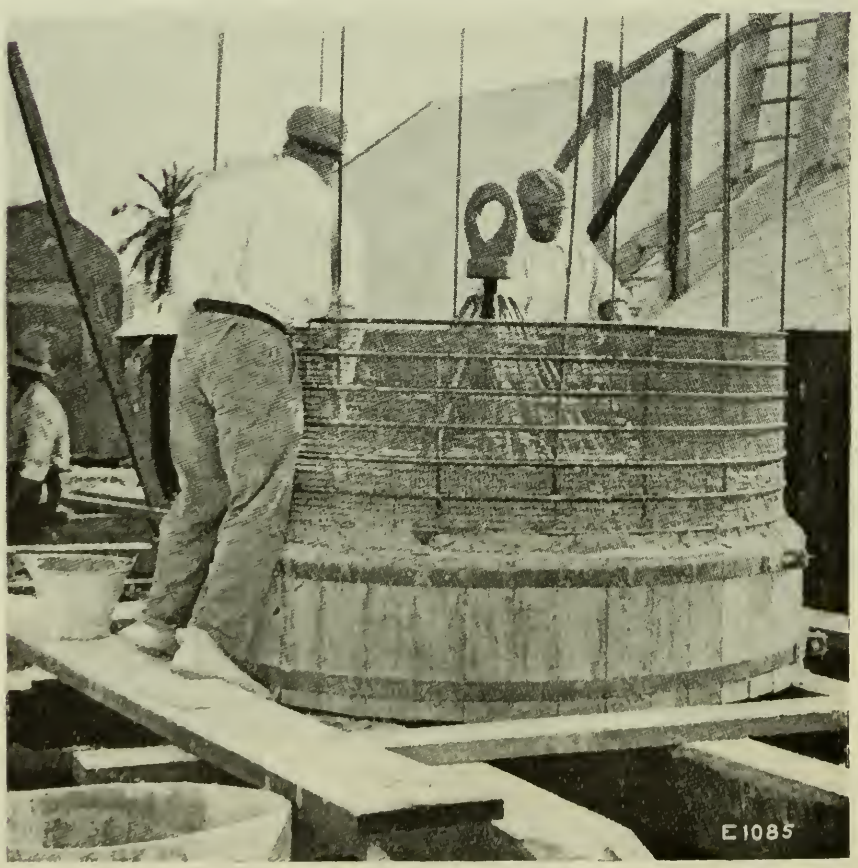
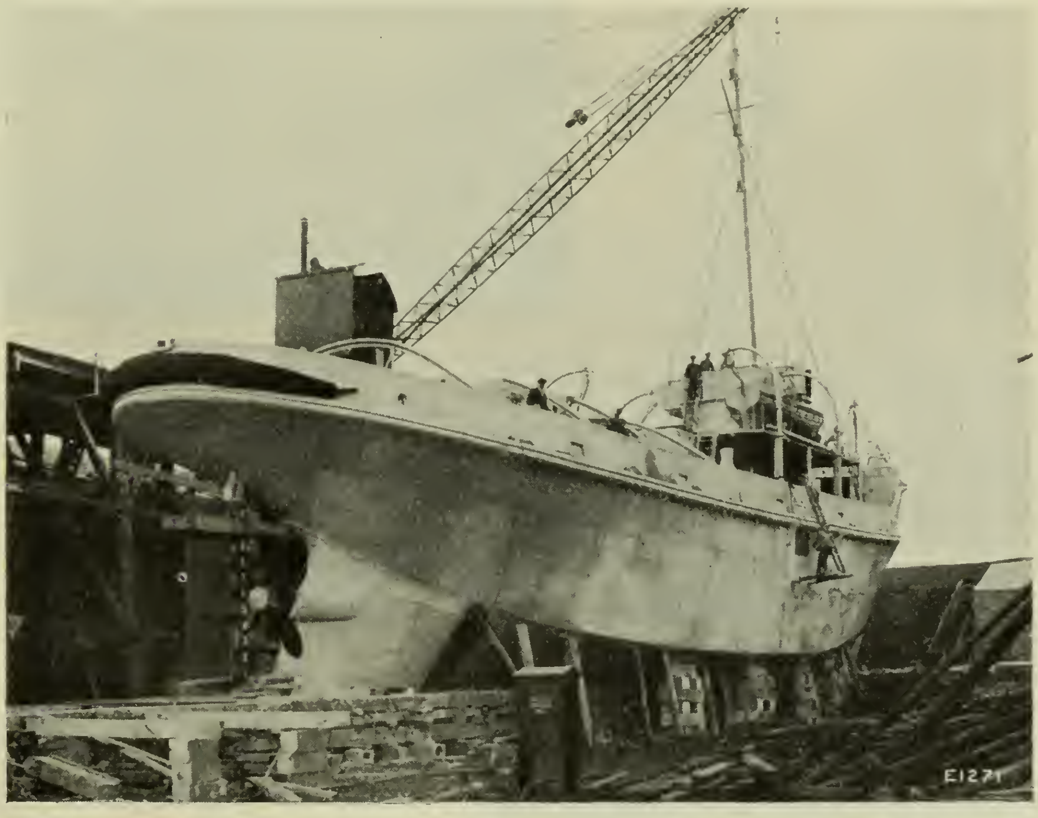


Fig. 158. A Concrete Buoy under construction.

A SEAGOING REINFORCED CONCRETE TUG.

THE possibility of using reinforced concrete is now one of the considerations of the engineer who is confronted with a structure for which the normal supply of labour and material is not to hand, and the methods by which it has been employed in the construction of the tug herewith described is of interest to all using this material or method of construction.

The vessel has been built by the Wear Concrete Building Co., Ltd., at Southwick-on-Wear, near Sunderland, where they have laid down entirely new works. These works, which cover a large area, have been planned and equipped with the latest facilities for constructing reinforced concrete works of all kinds, and in the portion set apart for the building of reinforced concrete ships, the first contract undertaken was for the construction of three powerful single-screw seagoing tugs for the British Admiralty.



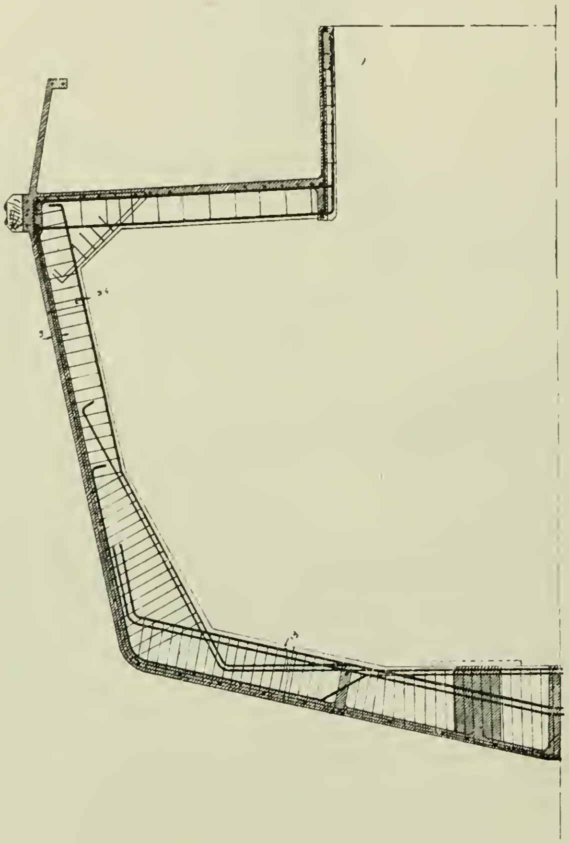
The contract originally let was for a large number of the vessels, but the coming of the Armistice led to its cancellation, except for the three tugs which were well advanced.

The first of these, which is here illustrated, was launched on Saturday, March 15th, of this year, and is the first reinforced concrete tug to be launched in this country.

Its chief dimensions are: 125 ft. long, 27 ft. 6 in. wide, and its depth 14 ft. 9 in. The design and construction of the vessel had perforce to be controlled by the uses for which it was specially designed, but it is well adapted for any requirement that days of peace may put upon it, and some interesting figures as to its construction and principal dimensions are given below.

Weights :—

Concrete	300 tons		
Steel reinforcements	35 tons		
		335 tons	
Castings, smithwork, wood, and outfit		59 tons	
Propelling machinery		130 tons	
Light weight			524 tons



Coal	85 tons	
Feed water	18 tons	
Stores	7 tons	
Dead weight		105 tons
Displacement		629 tons

Dimensions :—

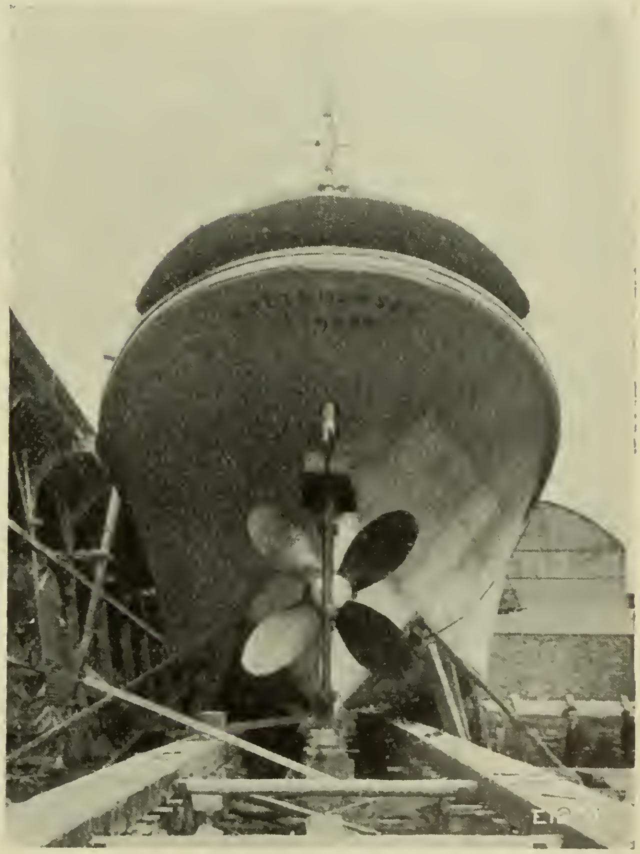
Length B.P.	125 ft. 0 in.	Extreme	134 ft.
Beam, mld.	27 ft. 9 in.	Extreme	29 ft.
Depth, mld.	14 ft. 9 in.		
Draft for 629 tons displacement	12 ft. 0 in.		

The vessel has been built for classification under Lloyd's register, but in the design arrangements were made for carrying a "merchant defence gun," and for resisting all strains and stresses that might be put upon the structure arising from its use.

General Arrangement.—The engines and boilers were made by the Central Marine Engine works of West Hartlepool. The triple expansion engine is of 750 indicated horse-power, steam being supplied by two single-ended boilers working under forced draught. On each side of the engine and boiler space are placed the coal bunkers.

In the stern of the tug a powerful towing winch is carried just abaft of a deckhouse containing the steering engine and entrance to the deck below, where a dozen men are accommodated. The forecastle has a turtle back deck, rendering the tug thoroughly seaworthy in bad weather, and acting as a shield for the windlass and anchor gear. Below the forecastle and the funnel is placed the galley and entrance to the officers' quarters. On the lower deck there are commodious cabins for the commander, the chief engineer, and four petty officers; and adjacent to these rooms is a dining-room and pantry. Below the cabin deck are the store rooms, a water tank and a chain locker.

Engine Foundations. — The bedding down of the engines to the concrete is effected by the casting of two longitudinal girders having steel projecting links.



The engines are placed on the top of these with the foundation bolts, which are provided with hooks hanging down on both sides of the concrete girders. Finally, concrete is poured on both sides of the girders, thus embedding the links as well as the foundation bolts.

Screw Fasteners.—The fixing of the deck fittings, etc., and the outside fenders is always a difficult problem in concrete shipbuilding, but has been overcome by the provision of special cast-iron screw fasteners, which were placed in position before the concrete was poured. These fasteners have projecting screws threaded to receive Whitworth bolts and the fixing is therefore as simple as in ordinary work.

Sternpost.—The sternpost has a forged L-shaped rudder post with a built-up stern frame, the latter being secured by longitudinal reinforcing bars passing through the angle bars of the frame itself. The whole sternpost, except the rudder post, is embedded in the reinforced concrete.

Frame Reinforcements.—The frame reinforcements were built up and electrically welded apart from the ship, and were then lifted bodily by means of a crane, and placed in position in the vessel.

The ships are built on the monolithic system of reinforced concrete construction, the steel reinforcements being placed in the forms in the position where they will remain, the concrete being then poured into the moulds. When the ship was placed on a wave of 1-20th of the length and the hogging, and sagging moments then found in the ordinary way, the result was 1/26 L. × Displ. in hogging condition, whilst the sagging moment was negligible. The ship was then designed for the sagging moment, 1/52 L. × Displ. The thickness of the skin and all bulkheads is 3 in., of the main deck $2\frac{3}{4}$ in., and of the accommodation decks $2\frac{1}{2}$ in. All the slabs have mesh reinforcement in both sides.

The frames are spaced at 4 ft. centres throughout the ship, except at the forward end, where they are 3 ft. centres. The dimensions of the web vary from 3 in. by 6 in. to 5 in. by 2 ft. 3 in. The centre keelson is 6 in. wide, and 1 in. higher than the floors, *i.e.*, 2 ft. 7 in., measured from the base line. The web of the side keelsons is 3 in. by 11 in.

For the reinforcement round bars, from $\frac{1}{4}$ in. to 1 in. diam. ; and also oval bars, $\frac{1}{4}$ in. by $\frac{1}{2}$ in., have been used. As can be seen (the general arrangement plan thwart ship), bulkheads are fitted on frames Nos. 1, 3, 7, 8, 13, 19, 20, 22, 29, and 31, and two walls run fore and aft between the bulkheads 13 and 22. This is necessary in order to divide the ship up into the various compartments required for a vessel of this type, but has of course rendered the execution of the work very extremely difficult, the working space being always very much confined, especially when compared with the open barge construction.

The ship has very fine lines, the transverse sections being straight lines, as shown by the shear draft. The 35 frames of the ship are all different, and this again added to the difficulty of the work.

The reinforced concrete design has been made by, and the work executed under the supervision of, Messrs. Peter Lind & Co., reinforced concrete engineers and contractors, of Parliament Mansions, Westminster, to whom we are indebted for the foregoing information.

ANNUAL GENERAL MEETING.

The following is a short abstract from the Annual Report of the Concrete Institute, together with a report of the proceedings at the Annual General Meeting held on May 22nd.—Ed.

A SUMMARY OF THE REPORT OF COUNCIL.

Generally.—The present membership of the Concrete Institute is 1,015.

In regard to publications, one of the Institute's activities in the previous twelve months was the preparation of a list of articles usually made in timber that could be suitably produced in reinforced concrete. The Board of Trade took a considerable interest in this, and printed it for the Institute, expressing its readiness at the same time to print a further edition as required. This also is now available for members.

Institute's Bronze Medal.—As the result of a ballot among members of Council, the Bronze Medal for the best paper read in the 1917-18 Session was awarded to Mr. H. J. Deane, M.Inst.C.E., for his paper entitled "Charterhouse Street Cold Stores of the Port of London Authority."

Steel Frame Conference.—There is nothing further at the moment to announce as regards the report of the Steel Frame Conference, which is still under consideration.

The Sub-Committee appointed by the Science Committee during 1917 to consider the use of high-tension steels for reinforced concrete work has been continuing its valuable labours, and the preparation of test specimens has been completed by a firm of contractors in Manchester, under the direct supervision of some of the members of this sub-committee. A report on these tests will be issued in due course.

Sub-Committees.—Before giving the usual list of the Standing Committees, reference should be made here to another Sub-Committee that was appointed during the year just expired, to consider the subject of reinforced concrete in shipbuilding. The first meeting of this committee was held in November, 1918, and the following were constituted members:

Prof. Henry Adams, Mr. D. B. Butler, Mr. J. S. E. de Vesian, Sir Henry Tanner, Mr. E. P. Wells, and Mr. G. C. Workman, with the following representatives from other authorities: Mr. S. F. Staples (Director of R.C. Construction, H.M. Admiralty), Mr. E. W. Colvill (Board of Trade), Mr. Charles Fowling (Lloyd's Register of Shipping), and Mr. J. Foster King (Institution of Naval Architects).

Sir Henry Tanner was elected to the chair.

The Committees appointed by the Council for the Session were as follow:—

FINANCE AND GENERAL PURPOSES COMMITTEE.

Chairman, Mr. H. J. Tingle; Vice-Chairman, Mr. G. C. Workman; Ordinary Members—Prof. Henry Adams, Messrs. H. K. G. Bamber, H. Kempton Dyson, E. Fiander Etchells, Major J. E. Franck, Messrs. Chas. F. Marsh, H. D. Searles-Wood, Sir Henry Tanner, Messrs. E. P. Wells, F. E. Wentworth-Sheilds, M. E. Yeatman; *ex-officio*, The President, and Chairmen of Standing Committees.

THE SCIENCE STANDING COMMITTEE.

Chairman, Mr. H. K. G. Bamber; Vice-Chairman, Mr. D. B. Butler; Hon. Secretary, Mr. Ewart S. Andrews; Hon. Secretary Research Committee, Dr. Oscar Faber; Ordinary Members—Profs. Henry Adams, T. Hudson Beare, Colonel J. D. Cormack, Messrs. H. J. Deane, H. Kempton Dyson, E. Fiander Etchells, Major J. E. Franck, Messrs. H. C. Johnson, Chas. F. Marsh, Dr. J. S. Owens, Messrs. W. G. Perkins, A. R. Sage, H. D. Searles-Wood, R. H. Harry Stanger, R. W. Vawdrey, E. P. Wells, F. E. Wentworth-Sheilds, M. E. Yeatman.

THE REINFORCED CONCRETE PRACTICE STANDING COMMITTEE.

Chairman, Mr. G. C. Workman; Vice-Chairman and Hon. Secretary, Mr. R. W. Vawdrey; Ordinary Members—Prof. Henry Adams, Messrs. Ewart S. Andrews, H. Kempton Dyson, Dr. Oscar Faber, Major J. Petrie, Mr. F. Purton, Major Lewis H. Rugg, Messrs. A. R. Sage, A. Alban H. Scott, Archibald Scott, H. D. Searles-Wood, T. B. Shore, J. M. Theobald, J. S. E. de Vesian, T. A. Watson, E. P. Wells, F. E. Wentworth-Sheilds, M. E. Yeatman.

THE PARLIAMENTARY STANDING COMMITTEE.

Chairman, Major J. E. Franck; Vice-Chairman, Mr. Osborn C. Hills; Hon. Secretary, Mr. Percy J. Black; Ordinary Members—Prof. Henry Adams, Messrs. W. E. A. Brown, E. Fiander Etchells, W. G. Perkins, E. O. Sachs, L. Serraillier, E. P. Wells; *ex-officio*, Mr. H. D. Searles-Wood.

The members of Council due to retire under the rules of the Institute are as follows: Dr. Faber, O.B.E., D.Sc., Major James Petrie, O.B.E., Mr. T. A. Watson, Assoc. M.Inst. C.E., Mr. M. E. Yeatman, M.A., M.Inst. C.E. These gentlemen were eventually re-elected to the Council, together with Mr. T. B. Shore.

Lieutenant A. W. Rogers, R.E., has been awarded the Military Cross. Major James Petrie and Dr. Oscar Faber were nominated to the Order of the British Empire.

Science Standing Committee.—The work of this Committee during the past year has been again chiefly concerned with research matters.

Reinforced Concrete Practice Standing Committee.—Beyond the final clearance for publication of the "Recommendations" previously referred to, this Committee early in the past twelve months undertook consideration of the manufacture of articles in reinforced concrete as a substitute for timber, to which, also, previous reference has been made. The Committee are now considering the subject of concrete dwellings, together with their waterproofing, and the question of thermal conductivity.

THE ANNUAL MEETING.

THE Concrete Institute held its Annual Meeting on Thursday, May 22nd, at 5.30 p.m., at Denison House, S.W., Mr. H. D. Searles-Wood, F.R.I.B.A., M.R.San.I. (The President), in the chair.

The SECRETARY announced the composition of the new Council as follows:

President: H. D. Searles-Wood, F.R.I.B.A., M.R.San.I.

Past-Presidents: Prof. Henry Adams, M.Inst.C.E., Sir Henry Tanner, C.B., I.S.O. (late Principal Architect, H.M. Office of Works), E. P. Wells, J.P., F. E. Wentworth-Sheilds, M.Inst.C.E. (Dock Engineer, L. & S.W. Rly.).

Vice-Presidents: E. Fiander Etchells, F.Phys.Soc., Charles F. Marsh, M.Inst.C.E., J. S. Owens, M.D., M.Inst.C.E., Edwin O. Sachs, F.R.S.Ed., A.Inst.Mech.E., Chairman of Executive B.F.P.C., etc.

Ewart S. Andrews, B.Sc.; H. K. G. Bamber, Assoc.Inst.C.E., F.C.S., Percy J. Black (District Surveyor for Wandsworth East), W. E. A. Brown, A.R.I.B.A., D. B. Butler, Assoc.M.Inst.C.E., F.C.S., Colonel J. D. Cormack, C.M.G., J. S. E. de Vesian, M.I.Mech.E., M.S.E., H. Kempton Dyson, Oscar Faber, D.Sc., Assoc.M.Inst.C.E., J. Ernest Franck, F.R.I.B.A., W. A. Green, M.A., B.Sc., B. L. Hurst, M.Inst.C.E., James Petrie, F.Perm.Way.Inst., F. Purton, F.S.E., A. R. Sage, A. Alban H. Scott, T. B. Shore, R. H. H. Stanger, Assoc.M.Inst.C.E., H. J. Tingle, M.Inst.C.E., R. W. Vawdrey, B.A., Assoc.M.Inst.C.E., T. A. Watson, Assoc.M.Inst.C.E., G. C. Workman, M.S.E., Morgan E. Yeatman, M.A., M.Inst.C.E.

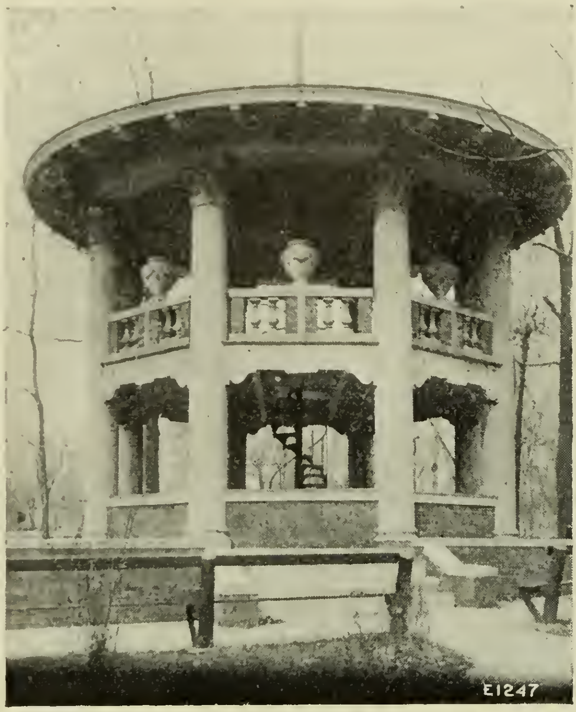
DISCUSSION.

Sir Henry Tanner, C.B., I.S.O., moved the adoption of the Annual Report of the Council, together with the statement of account and balance sheet. Having regard to the circumstances of the past year, the Report was, he thought, very satisfactory; the membership had increased, and the balance sheet showed a small sum in hand. In the course of his remarks he stated that the Shipbuilding Sub-Committee, of which he was Chairman, had held two or three meetings, but they had been unable to make much progress owing to the difficulty of obtaining authoritative information about the actual experience of concrete ships. The Admiralty had discharged their Department of Concrete Construction, which could have furnished that information, and the newspaper reports concerning the two or three concrete ships were too indefinite.

Mr. H. K. Bamber, Assoc.Inst.C.E., seconded, and the Report was adopted.

Messrs. Monkhouse, Stoneham & Co. were re-elected Auditors.

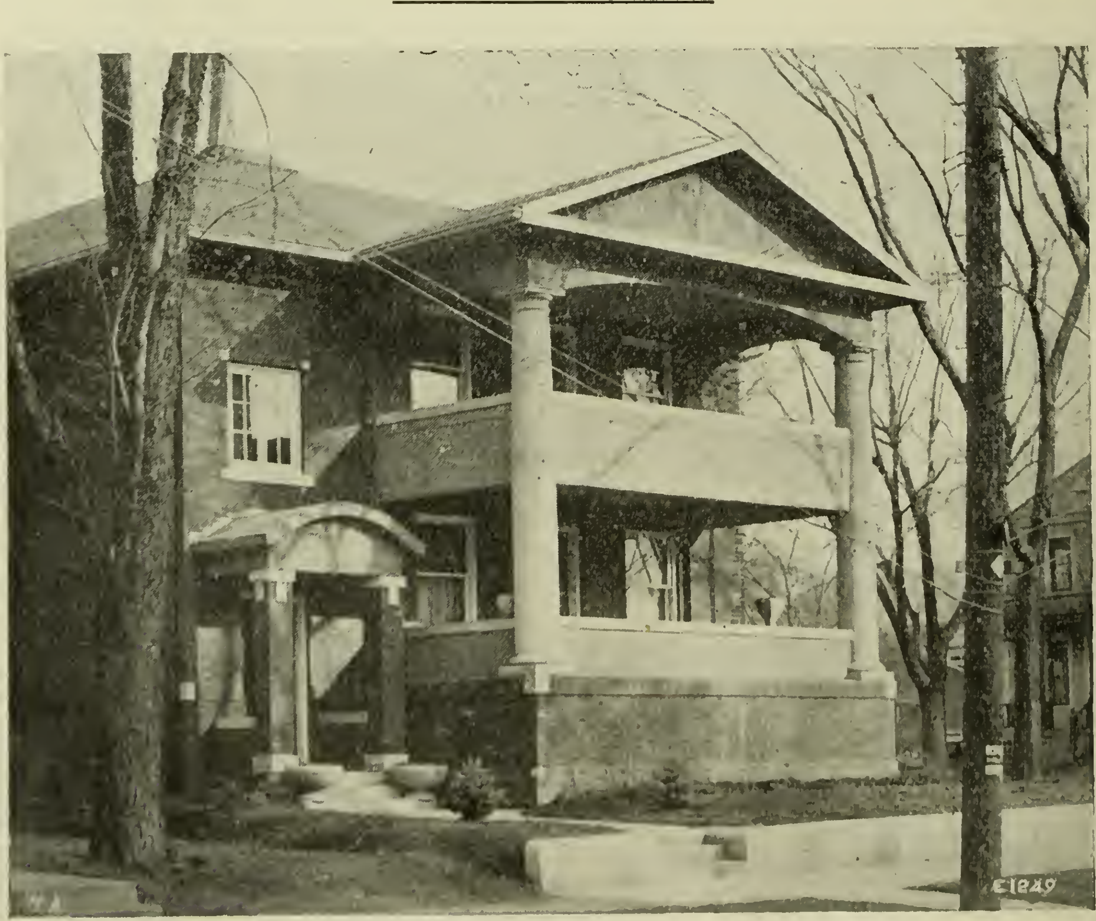
The Bronze Medal of the Institute was presented by the President to Mr. H. J. Deane, M.Inst.C.E., for his paper entitled "Charterhouse Street Cold Stores of the Port of London Authority," which had been adjudged the best paper read in the 1917-18 session.



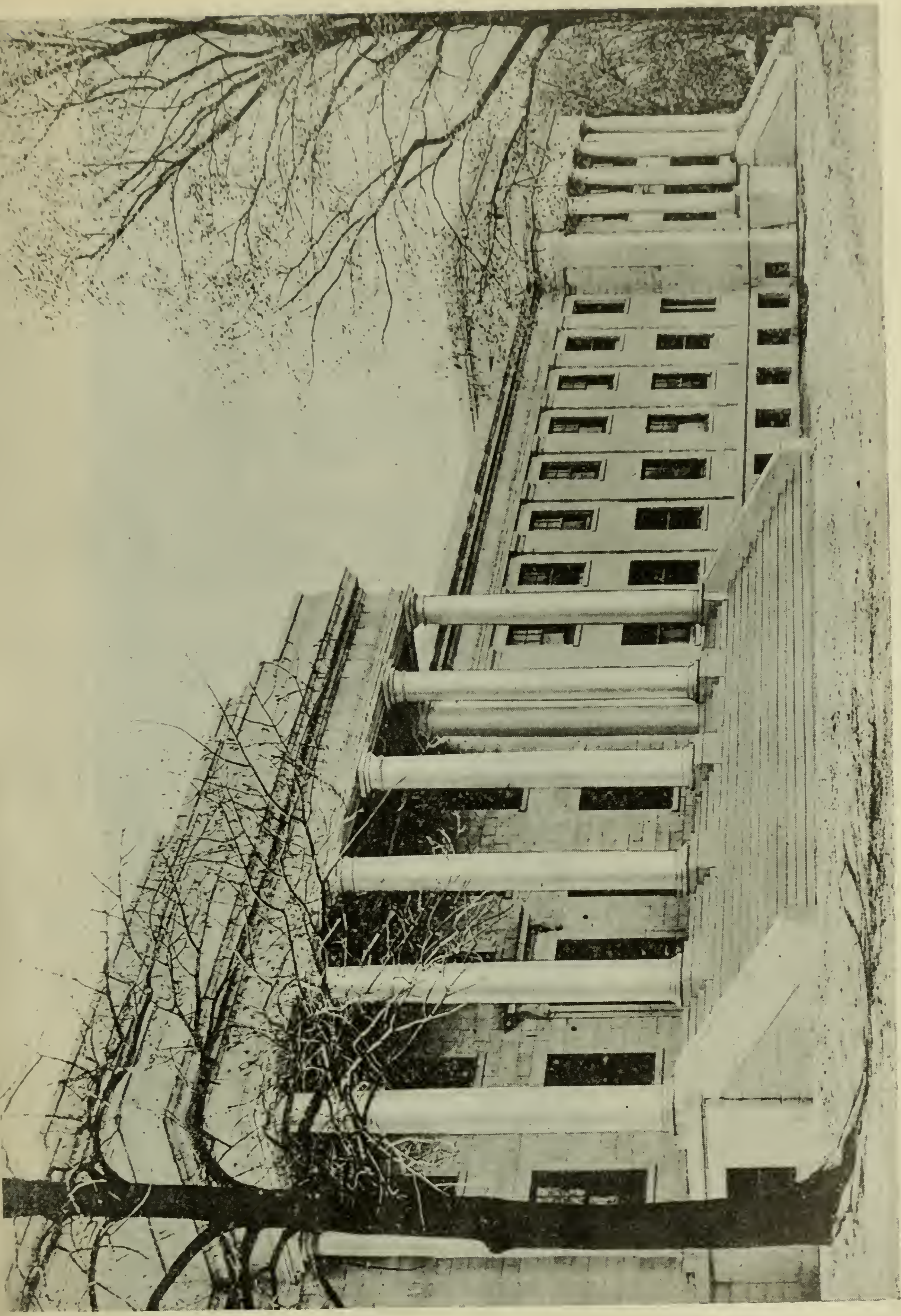
A Band Stand, So Park, U.S.A.

CONCRETE IN ARCHITECTURE.

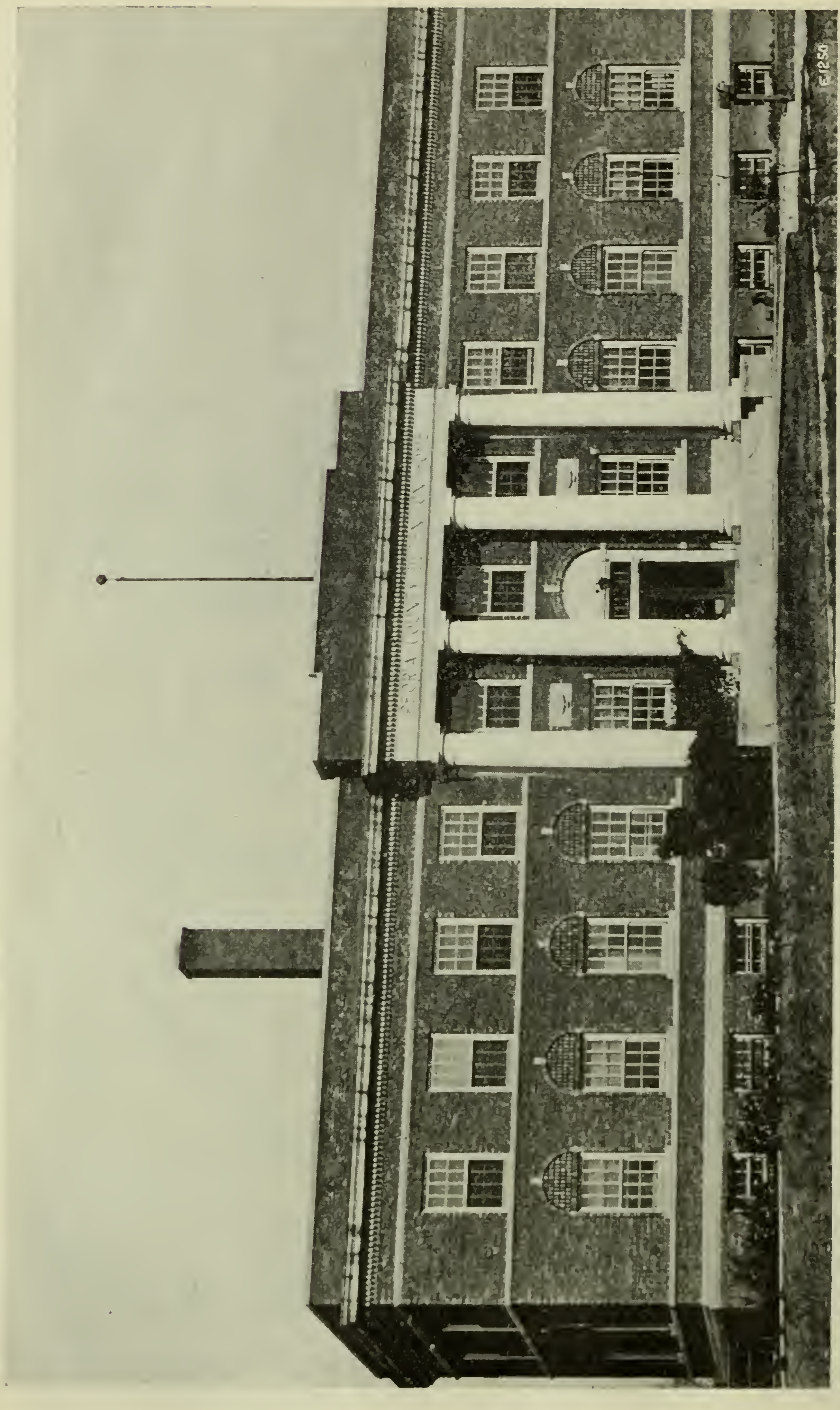
The following photographs illustrating the use of concrete for architectural work in public buildings are reproduced by the courtesy of the Synstone Corporation of Peoria, Ill.



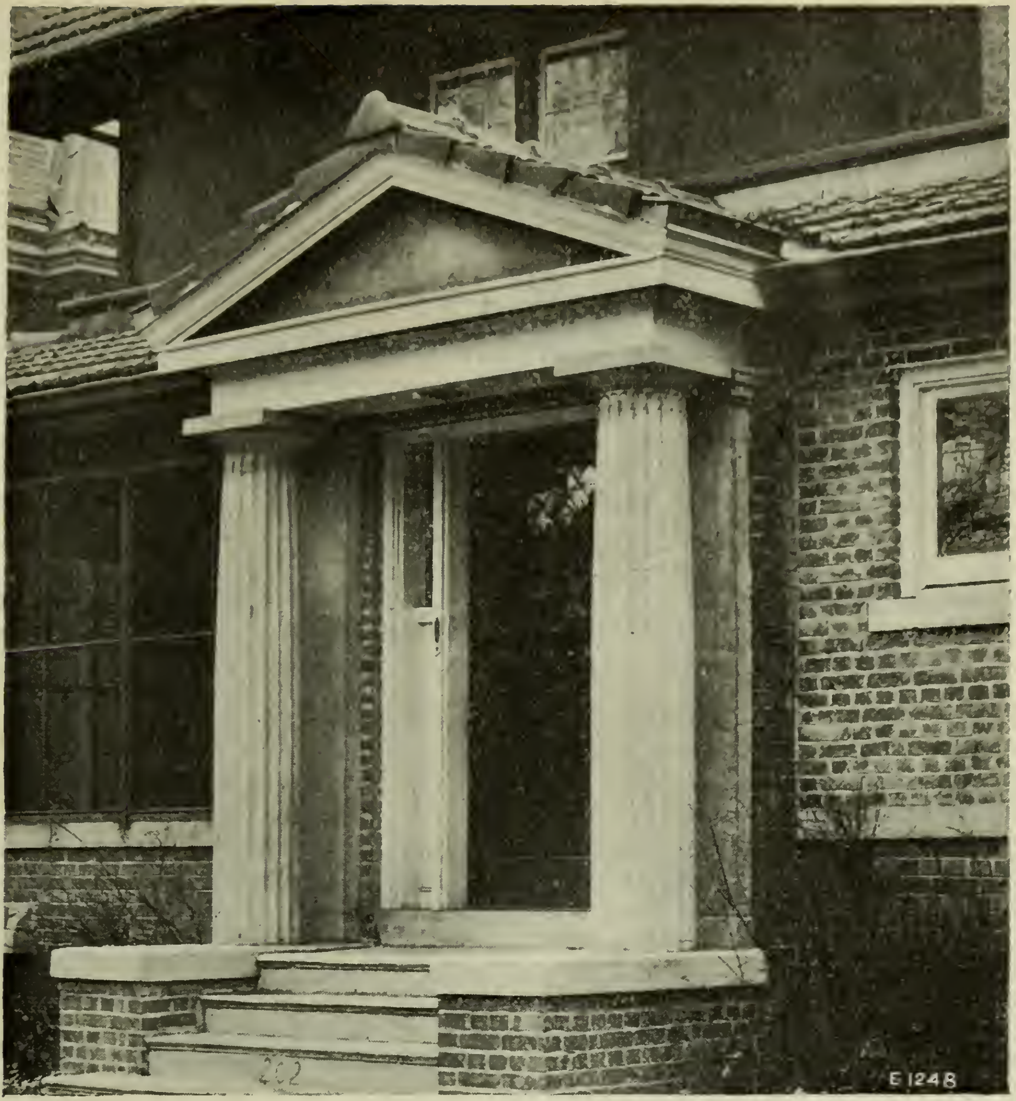
Entrance to a Private Residence. Columns and Urns of Concrete.



Military and Naval Academy, Lake Genova, Wisconsin.



The Peoria County Detention Home.



A Residence in Peoria, Ill.

In the accompanying illustrations concrete has been used for the architectural treatment of the buildings shown.

In the illustration shown of the Naval and Military Academy at Genova, Wisconsin, the walls and the columns are of concrete.

In the other illustrations concrete has been used for the columns.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE CONCRETE INSTITUTE.

THE GEOLOGY OF SANDS AND AGGREGATES FOR CONCRETE MAKING.

WITH SPECIAL REFERENCE TO TEXTURE.

By Professor **P. G. H. BOSWELL**, D.Sc.

The following is an abstract from a Paper read at the Eighty-eighth Ordinary General Meeting of the Concrete Institute on Thursday, May 22nd, 1919. *The President, Mr. H. D. Searles-Wood, was in the Chair.*

THE essential constituents of concrete are the aggregate, or lumps of broken materials, and the matrix, or binding substance, which is usually cement or lime. Frequently sand is also added to the mixture, or a fine-grained concrete may be made from sand and cement alone. The American connotation of the term "aggregate" includes sand.

In the specifications of the British Fire Prevention Committee the aggregates listed have been divided into two classes, natural and artificial. All the natural aggregates are necessarily rock substances, the description and occurrence of which come within the purview of geological science. The artificial aggregates result either directly, or as by-products, from the applications of industrial processes to geological materials. The natural aggregates include gravel (ballast), igneous (or fire-formed) rocks such as granite, basalts and other lavas, pumice, etc., and sedimentary rocks like sandstones, quartzites, limestones, etc., which were originally deposited under water or by wind, but which may have been subsequently altered by earth stresses or heat. The artificial aggregates include coke breeze, clinker, blast furnace slag, brick and terra cotta, and burnt clay. Materials analogous to all these artificial aggregates occur among the rocks of the earth's crust and have been produced in each case by the action of heat upon pre-existing rocks.

It is, however, with the geology of natural aggregates (which are used, except perhaps for the crushing, screening and washing, in the state in which they are wrought) that the following notes are concerned.

THE GEOLOGY OF AGGREGATES.

The rocks, which form the earth's crust, are classified into three groups according to their mode of origin. Those which have resulted from the cooling of molten magmas are known as *igneous* rocks, and their texture may vary from coarsely crystalline to glassy, according as they have cooled slowly or rapidly. Where steam and other contained gases have blown the rock into a froth, the material known as pumice is produced.

The decomposition of igneous (and other) rocks under the influence of such geological agencies as frost, rain water and heat, aided by running water and wind, results eventually in the accumulation of the débris at the bottom of the seas, lakes and rivers, or even scattered over the land. On account of the way in which they have arisen, such detrital rocks are known as *clastic* or *sedimentary*, the former term serving to remind us that they are composed of broken fragments of minerals or other rocks. Included in the "clastic" group are also rocks composed of the fragments and dust blown from volcanoes during their eruption.

Both igneous and clastic rocks may be subsequently altered as a result of the action of either heat alone (by contact with injections of molten magma) or of intense earth pressure, when the energy is frequently dissipated in the form of heat. In this way rocks belonging to the third group may be produced; they are said to be *metamorphic* because of the changes in mineral constitution and texture which have been produced in them.

In all the important industrial applications of rocks attention has to be paid either to the mineral composition or the texture—or frequently to both. The making of concrete proves no exception to the rule, but the present state of knowledge as to the effect of mineral constitution or even the ultimate chemical composition upon the setting of the concrete is not so complete as might be desired. Much more information regarding the effect of the size and shape (that is, the texture) of the aggregate upon the strength and durability of concrete is available.

THE CLASSIFICATION OF AGGREGATES.

In the specifications of the British Fire Prevention Committee* a not entirely inappropriate grouping (so far as use is concerned) of natural aggregates is made. Broken stone is classified thus :—

Ballast (gravel).
Volcanic rocks—(*a*) Basalts and dense rocks.
    (*b*) Lavas.
    (*c*) Pumice.
Granite.
Sandstones, limestones, quartzites, etc.

The geological purist would prefer to see the group of sandstones and quartzites more closely associated with ballast (gravel), to which these stones are genetically connected, and from which they differ only in grade. Limestones, both on account of their very different chemical composition, texture and fracture, as well as their different behaviour (at times) in the setting of concrete, might with advantage be placed in a class by themselves. Quartzites, sandstones, sand, gravel and limestones, would then form a sedimentary division, leaving "granite" and "volcanic rocks" to be placed in another division—the igneous rocks. The term "granite" in industry is reminiscent of the charity which covers a multitude of sins. Apparently, any rock which is reasonably hard, and which can be used for road material or paving setts, is termed granite. Not only are basalts and similar lavas included in the term, but even the quartzites of the Midlands, purely sedimentary rocks, have also been similarly classed. In the strict geological sense, a granite is a crystalline rock, which is the result of the slow cooling and crystallisation of a molten magma rich in silica. The cooling has usually taken place at considerable depth and under great pressure, and as a result the constituent minerals are equi-dimensional and well developed, and the rock therefore coarse-grained in texture. Granites consist of 65 per cent. or more of silica, which is partly present as quartz and partly in the form of silicates, such as felspars, micas, and other minerals like the amphiboles and pyroxenes. Coarse-textured rocks, like granite, which have originated in depth, are said to be "plutonic," and under this heading are included other rocks known as syenites, diorites, gabbros, etc., which have cooled from magmas of different chemical composition (for example, of decreasing silica content). The transition from granites to syenites and diorites is gradual, and it is not always easy in hand specimens to classify exactly any particular rock. No great harm would result commercially in many directions from calling all these plutonic rocks "granite" on account of the similar mode of origin (although the writer, as a geologist, would not be permitted to recommend such a plan). Before doing so in concrete specifications, however, it might be well to determine experimentally the effect in the aggregate of decreasing silica and increasing lime and magnesia (in the form of silicates) upon the setting qualities of concrete.

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* The writer understands that these specifications are at present undergoing entire revision. The results, however, are not yet published.

Under the heading of "volcanic rocks" in the specification are included separately "basalts" and "lavas." But basalts *are* lavas. Lava consists of rock, either fluid or congealed, which has been extruded at the surface of the earth and so has cooled under air or water. The association of the expression "dense rocks" with "basalts" in the grouping rather suggests that by basalt was meant a compact rock free from vesicles produced during solidification by escaping steam and gases, and by "lava" a vesicular or amygdaloidal rock. But many basalts are amygdaloidal (for example, the well-known Giant's Causeway rock), and some lavas are very compact.

Undoubtedly under the heading of basalt is included the group of rocks known to geologists as "hypabyssal," that is those cooled relatively near the earth's surface, intrusive into other rocks, but not extrusive into the atmosphere or sea. Amongst the hypabyssal rocks are the "whin-stones" (dolerites) worked so extensively in many parts of the British Isles for road metal, paving setts, etc. They occur as dykes and sills intruded into sedimentary rocks. "Porphyries" are the hypabyssal equivalents of the granites and syenites, and "dolerites" are the rocks corresponding to the diorites and gabbros.

A more natural grouping of the specified rocks would therefore be :—

A. Sedimentary rocks.
  (1) Sand.
  (2) Ballast (gravel).
  (3) Sandstones and quartzites.
  (4) Limestones.
B. Igneous Rocks.
  (5) Granite and other plutonic rocks.
  (6) Hypabyssal rocks, such as trap, whin-stone (dolerite), etc.
  (7) Compact volcanic rocks such as basalt.
  (8) Vesicular lavas, pumice, etc.

TEXTURE OF THE AGGREGATE.

For concrete making it is of importance as well as interest to know how coarse in texture the rock fragments may be and the character of their fractured surfaces. The latter depends upon their mineral constitution, which may also affect the setting of the cement. Other questions, which are concerned, for example, with binding qualities, dust-production, etc., have also to be considered.

We may now examine briefly the textural qualities displayed by the various rock types used as aggregate.

A. SEDIMENTARY ROCKS.

Sand.—The texture of sand, which is frequently used in addition to other aggregate, is considered separately in a later section of the paper.

Ballast (Gravel) is usually incoherent, as in the case of "Thames ballast." The question of cementing material therefore does not arise. Many of the pebble beds used for concrete-making are of comparatively recent geological age. To destroy the uniformity of size and roundness, the pebbles should be broken before use in concrete work.

Extensive pebble-beds, composed of rounded quartzite pebbles, occur in the Bunter beds throughout England and also in the glacial and river deposits formed from them (*e.g.*, near Doncaster, etc.). The pebbles are mainly about the size of the fist, and after crushing yield an admirable concrete-making quartzite material which has not been used as widely as it might. Very little washing of the crushed product would be necessitated. Resources are available in Devonshire, Dorset, the Midlands (near Birmingham), Derbyshire, Nottinghamshire, Yorkshire, etc.

Sandstones and Quartzites.—Sandstones and quartzites are the indurated rocks corresponding to sands. The cementing material may be—

(1) Silica itself, as in siliceous sandstones and quartzites.

(2) Clayey matter as in argillaceous sandstones (which upon metamorphosis yield micaceous quartzites or quartz-schists).

(3) Oxide of iron, either as hematite (Fe_2O_3), which is red; or limonite, which is hydrated and is yellow or brown ($2Fe_2O_3, 3H_2O$).

(4) Calcium carbonate, as in calcareous sandstones, or dolomite ($[Ca, Mg]CO_3$) as in the well-known Mansfield building stone.

(5) Other less important minerals such as phosphates, fluor-spar (CaF_2), barytes ($BaSO_4$), etc., which do not concern the concrete maker intimately.

Of the above cements the siliceous is undoubtedly the best for the purpose now being considered. It is generally accepted that soft sandstones are to be avoided for concrete; practically speaking, the bond is rarely siliceous in soft sandstones. The matrix of silica leads to great strength and clean sharp fracture of the rock, firstly on account of its hardness, and secondly because the silica frequently grows crystallographically on and in optical continuity with the surface of the quartz grains (being of the same chemical composition). The individual grains thus grow until they meet one another and interlock firmly. The structure can best be seen in polarised light under crossed nicols. Rocks of this character break across the sand grains and matrix equally and yield smooth plane surfaces and sharp edges. Soft sandstones may also be converted into quartzites of this type by re-crystallising effects of heat, or of earth stresses during mountain-building movements. Such quartzites would belong to the metamorphic class of rocks.

Cementing by argillaceous matter does not yield the best type of sandstones for aggregate, nor do the results of metamorphism upon such rocks yield a satisfactory product (see below). The latter is often a mica-schist or similar foliated rock.

Certain workers at the subject have stated that, far from being inimical, iron oxide in rocks may be useful on account of the chemical reactions into which it enters with the cement. Unfortunately most sandstones cemented with this substance do not show a desirable degree of compactness; a few, however, such as the Carstone of the Lower Greensand, particularly from Norfolk to Oxfordshire, are fairly hard.

Calcareous cements may be chalky and amorphous in character (when the resulting rock is soft) or composed of crystalline calcite (when a hard compact stone may be yielded). In the latter case, as in quartzites, the fracture of the stone breaks across the sand grains and not round them—a very desirable property in concrete making. Occasionally "in the field" we meet with natural concrete—known as "calcrete"—formed by the cementation of sands and pebble beds by lime originally in the form of carbonate. The matrix frequently shows no effervescence at the present time with acid, tricalcic silicate having probably been formed, as in the setting of cement. Calcite can be scratched with a knife; quartz cannot. Aggregate of calcareous sandstone therefore shows heterogeneity in hardness as well as composition.

Portland cement containing more than 8 per cent. of magnesia is objected to on the grounds that expansion and loss of strength are likely to occur in the course of time. It would therefore appear that sandstones cemented with dolomite should, if possible, be avoided.

Other cementing media are of local occurrence only and are mainly of geological interest.

Limestones.—Limestones may be produced by organic action or by chemical precipitation from the waters of lakes and seas.

Soft limestones are not suitable for concrete making, nor, on the whole, are those of organic or oolitic origin. They tend to break and flake irregularly, and an oolite rarely breaks across the grains. Crystalline limestones have a sharp clean fracture and are homogeneous, but glide-planes are very easily set up in calcite crystals by pressure. Calcite has also an excellent cleavage; deformation and fracture are thus liable to take place. Limestone is neither as hard, nor structurally as strong, as quartzite.

B. IGNEOUS ROCKS.

Granite and other Plutonic Rocks.—Whereas most sedimentary rocks consist of grains cemented together by chemically similar or dissimilar material, igneous rocks, from their very mode of origin, are made up of grains of minerals crystallised together. Various types of structure are produced, but the essential feature is the close contact and interlocking of the grains.

The plutonic rocks, having cooled slowly and often under great pressure, are coarse-grained and the individual minerals are on the whole equi-dimensional. This texture has been termed *granitic* from its being exhibited so frequently by granites. Where the individual minerals tend to take a somewhat rounded shape and uniform size, the texture has been called *granular*. In the diorites the grain is as a rule smaller than in granites. The constituent minerals of a typical granite are quartz, felspar and mica ; hornblende and pyroxene may also be present. Quartz is much harder, and less prone to chemical decomposition, than the other minerals mentioned. Although these differential qualities might affect the value of crushed granite as a concrete-making material, most writers on the subject see little difference in the results yielded by granite and diorite, which is largely composed of felspar and hornblende or pyroxene, minerals more similar in hardness and in proneness to decay.

Hypabyssal Rocks.—Many of the " traps " and " whin-stones " are finely granular in texture, the individual crystals being too small to be seen by the naked eye. Occasionally there are larger crystals, known as *phenocrysts*, set in a fine ground-mass of small crystals. The structure is then known as *porphyritic*. The phenocrysts are large enough to be detected in hand specimens of the rock. Another structure frequently shown by members of this group of rocks is that known as " *ophitic* " from its snake-like appearance. During cooling, one of the minerals has crystallised out in aggregates of somewhat lath-like form, which interlock with and wrap round other constituents of the rock. Frequently either of the aggregates behaves under polarised light as an optically continuous crystal. The minerals, felspar and augite (pyroxene), which are commonly the constituents of dolerites, exhibit this feature well. Undoubtedly ophitic structure leads to density, sharpness and cleanness of fracture, and strength in concrete-making aggregate. Dolerites, traps, and whin-stones are therefore popular materials. Microgranites are the hypabyssal equivalents of the granites and show a fine-grained granitic structure.

Compact Volcanic Rocks.—The important members in this group, arranged in order of decreasing silica-content (and therefore of increasing specific gravity), are Rhyolites (and also Obsidians and Pitchstones), Trachytes, Andesites and Basalts. Rhyolites and Trachytes are frequently not as compact as the others ; moreover, although they have been employed, they are of too limited distribution in the British Isles to be used extensively for aggregate.

Vesicular Lavas (Pumice, etc.).—The decrease in pressure which accompanies the extrusion of a lava at the surface of the earth results in the release of contained gases, steam, etc., which render the upper part of the flow frothy, and cause the bulk of the rock to be riddled with steam-holes, known as vesicles. Often these are drawn out into almond-shaped cavities by the sluggish flow of the congealing rock. The cavities may be filled in subsequently by minerals which have crystallised from solution (amygdales, *amygdaloidal* structure). The fracture of such rocks is irregular, and the voids are great.

METAMORPHIC ROCKS.

It does not appear that apart from quartzite and crystalline limestones, rocks of metamorphic origin have ever been extensively used in concrete work. They are not specifically mentioned in British specifications ; in the American connotation of the term " granite," however, both gneiss and mica-schist are included.

SANDS FOR CONCRETE MAKING.

Sand, as previously noted, may be regarded as an aggregate itself or as a third constituent in concrete. It is used so extensively for mortars and concretes as to justify a separate treatment. Materials like sand, loam and clay are as much rocks to the geologist as granite and basalt.

Sand plays the role in concrete-making of a filling material intermediate in size between the aggregate and the cement. It therefore tends to assist the production of smooth surfaces. To obtain a minimum of voids and a maximum of strength the gradation of the sizes present in the aggregate should be as perfect as possible. Any attempt to carry this proportional spacing of weights of aggregate over grade-sizes down to sand would lead to the production during crushing of large quantities of dust and fine material. Much washing would therefore be necessitated. It is more advantageous to break and screen the aggregate down to the size of very coarse sand and to fill in the smaller voids with coarse and medium sand (50 to 20 or 30 mesh). Fine sand has been found to weaken the strength of the concrete. On the same principle (of perfect spacing of grades) it is desirable that the sand used should not be " well graded," that is, have all its grains of the same diameter. Sand composed of mixed grades contains fewer voids and reduces the quantity of cement required.

Composition of Sands.—It may be well to consider briefly the special qualities required in sands used for concrete. Analyses of sands may be made from three different standpoints. They may be subjected to chemical analysis, and their composition expressed ultimately as a series of oxides. With few exceptions sands are found to consist of 80 to 99 per cent. of silica (SiO_2). Alumina (Al_2O_3), iron oxides (FeO and Fe_2O_3), lime (CaO), magnesia (MgO), and the alkalies—soda and potassia (K_2O and Na_2O) are the chief remaining constituents. As an example we may quote the analysis of a sand from Leighton Buzzard, Beds., well known to those interested in concrete :—

	Leighton Buzzard Sand (washed). Chemical Anaylsis.
SiO_2	99.05 per cent.
Al_2O_3	0.23 ,,
Fe_2O_3	0.14 ,,
MgO	0.08 ,,
CaO	0.31 ,,
Na_2O	None.
K_2O	None.
Loss on ignition	0.31 ,,
	100.12 per cent.

Such a sand is, of course, exceptionally pure.

Sands may also be analysed from a mineralogical point of view. The variety and proportions of their constituent minerals are determined by certain special methods, a description of which may be found in modern geological text-books.

Texture of Sands—Mechanical Analysis.—Neither the chemical nor the mineral constitution of sands concerns the concretor very closely, although he uses them on account of their quartz-content. It is only when they contain the clayey decomposition products of the felspars and certain of the heavy minerals that he raises objections. By the mechanical analysis of a sand or aggregate we seek to determine the sizes of the constituent particles or lumps, and the percentage weight of each portion between certain agreed limits of size (" grades "). A definite nomenclature for the smaller grades is very desirable in practice, and the following scheme, based on the metric system, has been found of great service geologically :—

Approx. I.M.M. Mesh.					
	G	Greater than 2.0 mm. diam.		Gravel Grade [G]	
12–5	VCS	,, ,, 1.0 ,,	and less than 2.0 mm.	Very coarse sand	Sand grade [S]
20–12	CS	,, ,, 0.5 ,,	,, ,, 1.0 ,,	Coarse sand	
50–20	MS	,, ,, 0.25 ,,	,, ,, 0.5 ,,	Medium sand	
120–50	FS	,, ,, 0.1 ,,	,, ,, 0.25 ,,	Fine sand	
180–120	cs	,, ,, 0.05 ,,	,, ,, 0.1 ,,	Superfine sand or coarse silt	Silt grade [s]
——	fs	,, ,, 0.01 ,,	,, ,, 0.05 ,,	Silt	
——	c		less than 0.01 ,,	Clay or mud grade [c]	

Mechanical analyses of aggregates as well as coarse sands may be effected by screening.

Except for the I.M.M. screens (that is, those conforming to sizes laid down in specifications by the Institution of Mining and Metallurgy) where the diameter of the square aperture is equal to that of the wire, no uniformity or standardisation in sieves exists. Moreover, they are only moderately accurate even when round-holed and made from perforated copper or brass. In any case, sifting is no longer possible for accurate separation when the grades are less than half a millimetre in diameter. Material of this size or less is analysed by the process known as elutriation, which consists in separating the sediment into grades by means of suitably-controlled currents of air or liquid (usually water). Elutriation by means of wind-currents is utilised industrially in cement manufacture and in the preparation of silica flour, in both cases after the final grinding. For scientific work, air separation is found to be insufficiently accurate and sediments are therefore subjected to mechanical analysis by elutriation, with upward currents of water as the lifting agents.

In view of the fact that the maker of concrete requires coarse sands, free from finer grades, silts and clayey matter, it is unnecessary to deal with elutriation in detail. It is generally agreed that the sand used should not be smaller than 30-mesh, or at the extreme 50-mesh material.

The grain size is undoubtedly the most important factor in concrete-making sands, and it is frequently specified that the sand shall not be less than 30-mesh. The so-called "Standard" sand for cement testing, road metal abrasion, etc., is defined in Britain and the U.S.A. as a natural sand which passes a screen having 20 meshes to the linear inch (0.63 mm. diameter) and is retained on a screen having 30 meshes to the linear inch (0.42 mm. diameter). In the classification adopted above, it corresponds most closely to the coarser part of the medium sand grade. The U.S. standard sand is wrought at Ottawa, Ill., and is a highly rounded sand. The British standard sand is worked at Leighton Buzzard, and is composed of subangular grains (which however is not of "standard" size).

The French Standard Sand is said to come from Leucate, France, and is simple or compound. The simple standard sand must pass a screen having holes 1.5 mm. in diameter (0.06 inch) and be retained on one having holes 1 mm. in diameter (0.04 inch). The compound Standard Sand is made by preparing a mixture from equal weights of the following grades :—(*a*) 2 mm. to 1.5 mm., (*b*) 1.5 mm. to 1 mm., (*c*) 1 mm. to 0.5 mm.

The German Standard Sand corresponds to the British in size, but the major limit is slightly less (28-mesh). The Austrian Standard Sand is also of similar size.

It is noteworthy that most of the fairly pure British sands are of rather smaller grade than the Standard Sand.

The vast and unsightly tips of sand left as a result of the washing of decomposed granite in Devon and Cornwall for the purpose of obtaining china clay are of the grade suitable for concrete. The material may be obtained cheaply and its utilisation would be a public service.

It would be desirable at some future time to place on record a full description of British resources of sands suitable for concrete-making.

Most British sands are subangular in grain. At a few geological horizons, notably the Trias and Permian, rounded grains are abundant. The products obtained by crushing quartz are flaky and splintery, and are not suitable for concrete-making on account of the excessive quantity of voids they yield. Flint is open to the same objection. The hardness of the mineral grains of a sand, and their freedom from cracks, etc., are matters of importance.

The opinion that there is little to choose in the use of sand between subangular or rounded grains is now gaining ground.

In a perfectly graded sand or aggregate composed of uniform spherical grains the percentage of voids varies according to the type of packing. Theoretically, the voids form 47.6 per cent. of the bulk when each sphere rests on one other ; 39.5 per cent. when each sphere rests on two others ; and 25.95 per cent. when each sphere rests on three others—obviously the method of closest packing. Other arrangements of the spheres also give the last result, which, as the late H. C. Sorby pointed out,* serves to indicate that even when occupying the least volume, the spheres could move about considerably without increasing the proportion of voids. Sands when deposited do not take up an arrangement leading to minimum voids. Shaking or compression, due respectively to earth movement or weighting by accumulated strata above, etc., may reduce their voids. In no case did Sorby succeed in reducing the voids even of fine sand below 34 per cent., the same sand unshaken having had about 47 per cent. voids. Sandstones, oolitic limestones and similar rocks may be regarded as natural concretes. It is therefore of interest to recall Sorby's work on the interspaces of such rocks. The cementation of the grains naturally reduces the quantity of voids, which often sink below 20 per cent. In certain cases the proportion falls to 6 per cent. and Sheffield Gannister, as a result of infilling by secondary quartz, contains less than 1 per cent.

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* See Quart. Journ. Geol. Soc., Vol. 64 (1908), p. 181. See also, U.S. Geol. Survey, Water Supply and Irrigation Papers, No. 67 (1902), and 19th Annual Report, Part V. (1899).

Washing of Sands, etc.—The effective washing of sands and aggregate to be used for concrete making is a matter of great importance. A perfect solution of the problem cannot yet be said to have been evolved. Some method of "scrubbing" is the only way to clean ballast effectively from adherent clay and loam. On the other hand, the dust produced in the crushing of aggregate can easily be washed away. If the aggregate is required down to 50-mesh, an upward current of water at ordinary temperatures of about 5 feet per minute (or 1 inch per second) will remove all material smaller than this. If sand is to be added and the aggregate is in consequence required to be not smaller than 20-mesh, a velocity of about 15 feet per minute will remove the material not required. Many types of sand-washing machines are in operation throughout the country. Fortunately the grade of sand required for concrete-making is a size which will wash without difficulty; considerable losses are experienced with fine-grained sands. The objection to most sand washers in use is that the water first washes the dirty sand, and then, before it leaves the apparatus, is filtered again by the clean sand; much of the clayey and vegetable matter thus remains in the sand.

GRAPHICAL REPRESENTATION OF GRADES.

A considerable amount of work has been done in the graphical expression of the grading of aggregate for concreting—more perhaps than in any other industry.* In many cases the object has been the synthetic preparation of mixtures. The principle adopted by the writer in expressing graphically the mechanical analyses of sands is similar to that in use for concrete materials, but there are slight differences in detail which may make it of interest to record the method. The expression of mechanical analyses in the form of curves brings out contrasts and similarities in sands and aggregates more graphically than does any other method. The curves are of course only approximations at the best. Cumulative percentages by weight of material *above* the grade-size (marked horizontally) are set off vertically as ordinates. The horizontal scale adopted is proportional to the logarithms of the diameters marked, in order to keep the scale representing the various grades within the compass of the page.

Horizontality in any part of the curve means the absence of the material of the grade size corresponding to the distance over which such horizontality extends. Verticality in the graph means a considerable percentage in the grade size corresponding to the position of the vertical portion.

In the above brief consideration of certain geological aspects of aggregates and sands for concrete-making, the field has been so large and time and space so small, that the account has necessarily rather taken the form of notes not always too well linked. It would have been desirable to have given a brief account of British resources of all the rocks mentioned—particularly of quarries, etc., where spalls left in the dressing of building-stones and setts are available. The fact that such information is not at present available serves to indicate the tendency, which has been universally shown in the past, to record national resources of what might be called "precious" commodities like coal and metallic ores, but to ignore the "everyday" materials like limestone, sandstone, gravel and sand, which are consumed in enormous quantities for numerous industrial purposes.

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* See, for example, Taylor and Thompson, "A Treatise on Concrete." 3rd Edn., 1916. New York

DISCUSSION.

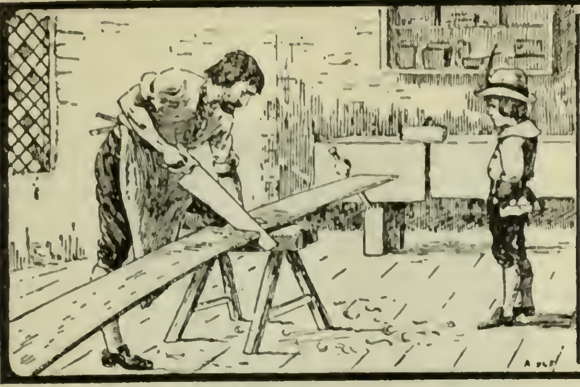
Mr. Ewart S. Andrews asked the author's opinion, as a geologist, as to the possibility of Portland cement lasting the same time as the cements used in Roman concrete.

Mr. D. B. Butler, referring to the statement that Portland cement containing more than 8 per cent. of magnesium was objected to on the ground that expansion and loss of strength was likely to occur in the course of time, pointed out that the British Standard specification allowed only 3 per cent. and some of the American specifications allowed only 4 per cent. He thought the sample of Leighton Buzzard sand, of which the author gave a chemical analysis, was exceptionally pure. It contained 99 per cent. of silica, whereas his own records did not give a higher figure than 96 or 97 per cent. Reference was made in the paper to the want of uniformity in the meshes in various sieves used for testing. That question was discussed very seriously some years ago with regard to cement testing. There was then no uniformity at all in the thickness of the wire used. One maker would make a 100-mesh sieve of .003 inch wire and another of .004 inch wire, so that there was a big difference in the actual size of the opening through which the material had to pass with corresponding confusion in the results obtained in different laboratories. Before the British Standard specification was brought out it was the custom in America and on the Continent for the thickness of the wire to be half the thickness of the opening. According to the Institution of Mining and Metallurgy specification the diameter of the square aperture was equal to that of the wire. That meant that in a 100-mesh sieve the thickness of the wire would be .005 inch, and as the hole had the same diameter it would be very much finer than it should be. As to the use of the sand washed out from china clay, he had had occasion to examine a concrete made in this way and it certainly was a first class material. Unfortunately, in the particular instance, the concrete had been starved of cement and the final result was not altogether satisfactory. It would not pay for transport over long distances, however, and would have to be used locally.

The President, referring to the comparison between Portland cement and Roman concrete, said it would be extremely interesting if the original military specification under which Roman concrete was made could be found. It was a most remarkable thing that wherever one went in Europe it was found that Roman concrete was made to exactly the same specification and of exactly the same materials, and how it was done he could not imagine. It was always understood that the durability of Roman concrete was due to the pozzuolani, which contained free silica. Some materials from the Rhine had been put on the London market for concrete purposes which was said to have contained pozzuolani, but of course in present circumstances that was not now coming to England.

THE LECTURER'S REPLY.

The Author, replying to the discussion, said the 8 per cent. magnesium he had referred to was an outside figure, and had been taken from an American specification. The difficulty with regard to screens in the past had been that the diameter of the wire varied with the price of copper or brass. As the price went up the thickness of the wire decreased and the diameter of the aperture increased. The sieve makers openly admitted this. The Institute of Mining and Metallurgy screens were used because the thickness of the wires was definitely equal to the diameter of the aperture. That was all right when small screens were used, but with the coarse screens the wires were extremely thick. The Leighton Buzzard sand, of which he had given a chemical analysis, was purer than that usually supplied for concrete making, but it was an average sample of that used for refractory purposes. The question of the Roman specification, he was afraid he was not competent to deal with.



SOME AIR SHEDS AND A LABOUR REST CAMP ON THE HY-RIB SYSTEM.

The following illustrations show some Air Sheds and a Labour Rest Camp constructed during the war period. For our particulars and illustrations we are indebted to the Trussed Concrete Steel Co., Ltd.—ED.

In order to meet the increasing need for aeroplanes during the war it was necessary to erect additional sheds and hangers at very short notice.

In the early days of the war many of the temporary hutments and other buildings were erected with timber, but as timber became scarcer and dearer, recourse was had to other materials.

In a large number of the buildings the main framework is of structural steel, and a form of reinforcement known as " Hy Rib " in some cases being used for walls, roofs, and internal partitions. This reinforcement, particulars of which have appeared in our pages, is securely fixed to the steel members, afterwards being concreted to a total thickness of 2 to 2½ in.

The illustrations here shown are of some flight service sheds and a Labour Rest Camp.

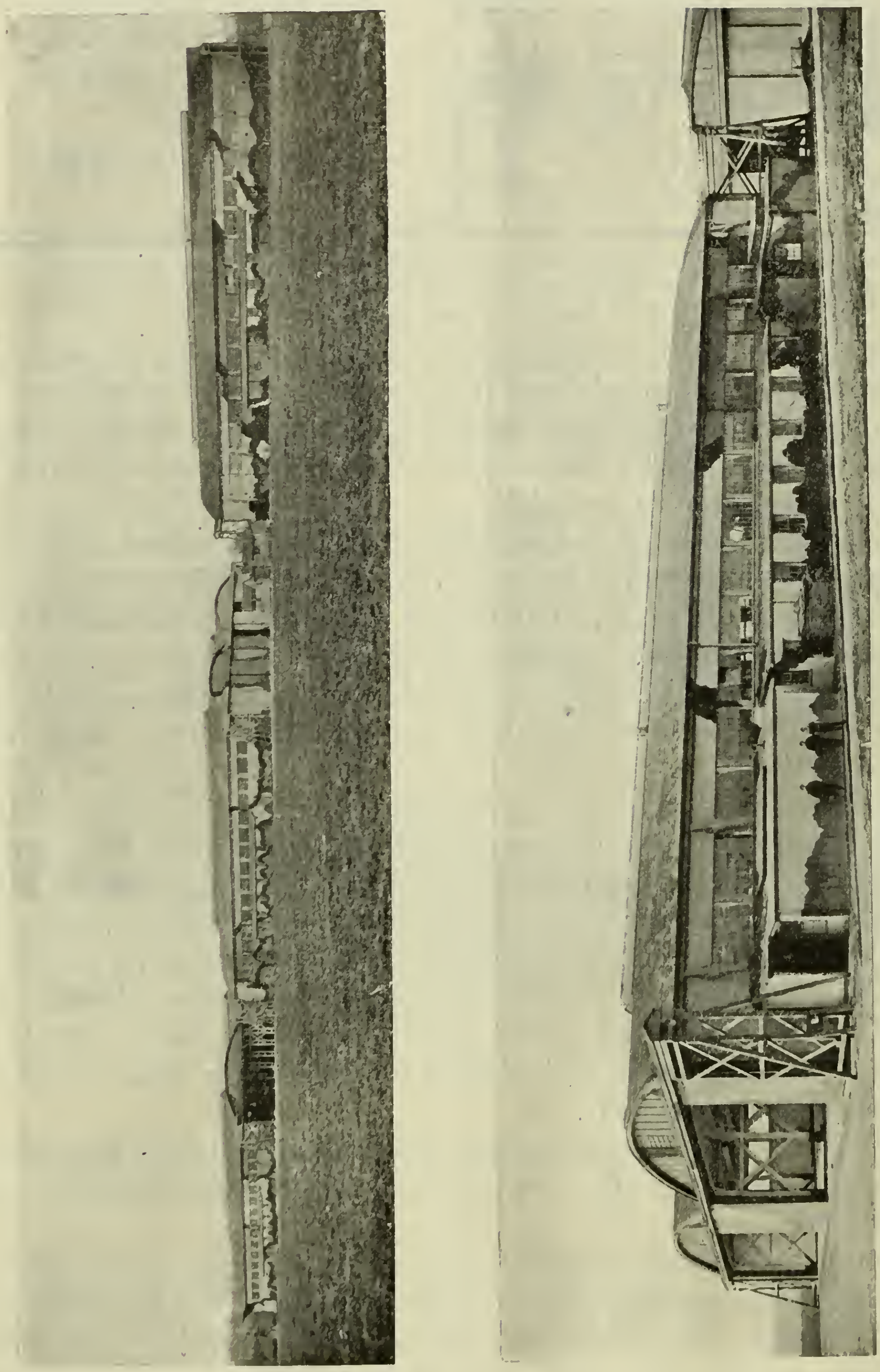
The flight service sheds are 170 ft. long.

The outside walls are constructed with uprights at 10 ft. centres to which the " Hy Rib " is attached, and then plastered to a thickness of 2 in. These uprights in the early days of the war were usually of timber, but later on concrete uprights were adopted. These were cast on the ground *in situ* and " hairpins " of 14 gauge wire were cast in the columns at the time the concrete was being poured, and this gave a convenient method of fixing the " Hy Rib " after the columns were erected in place. The span of the sheds was usually 80 ft.

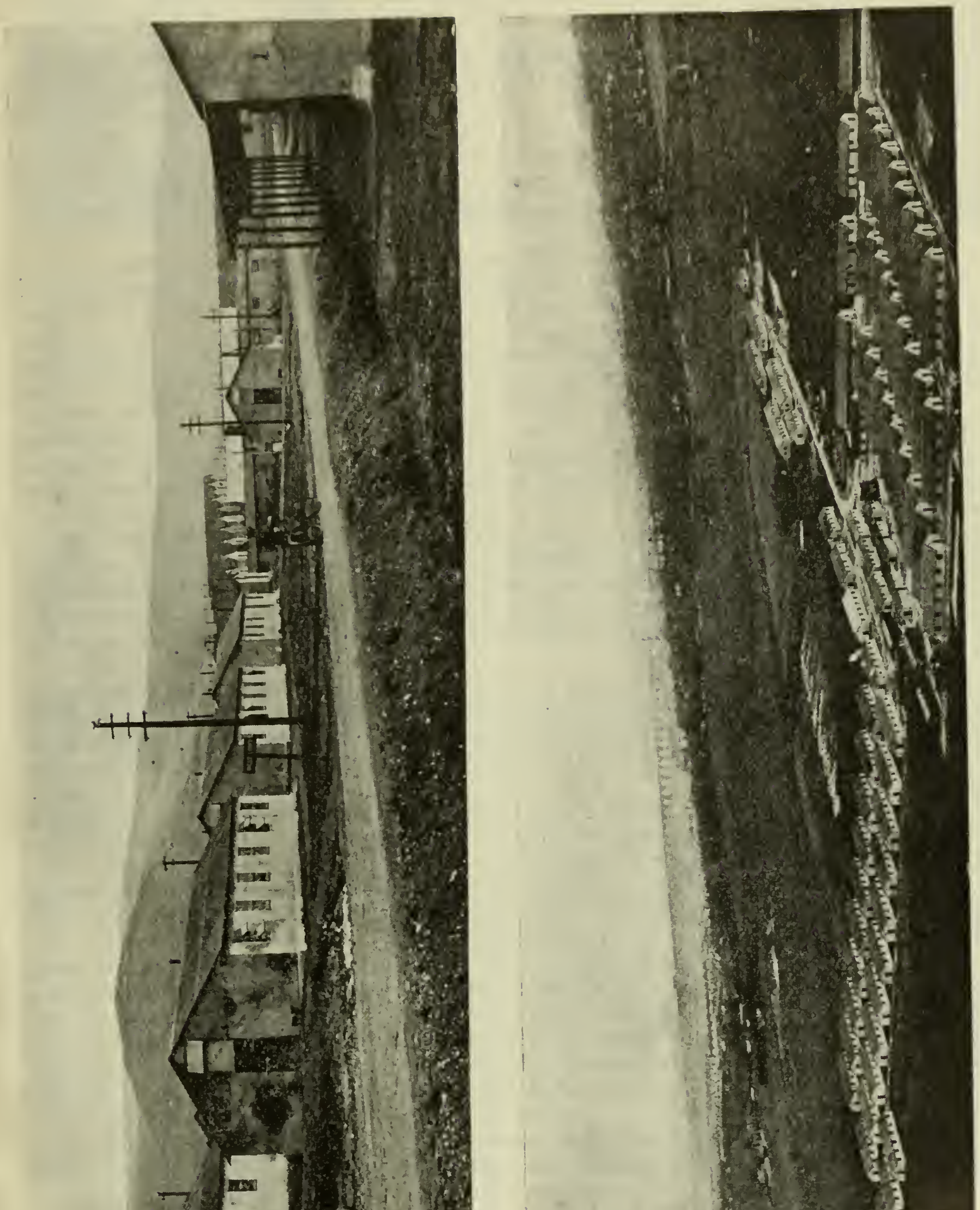
It will be seen that in this manner where unskilled labour can partially be taken advantage of, walls, partitions, etc., of substantial rigidity can be quickly formed.

The rest camp shown comprises over eighty dwellings in all, the " Hy Rib " being used throughout for the walls, partitions, and in certain cases also for the roofs. The buildings as shown were required at short notice, and it was essential they should be weatherproof and fire-resisting and conform to the standard of household dwellings.

We are informed that the authorities were very satisfied with the finished buildings.



Some Air Sheds.



Labour Rest Camps.

THE FOREIGN PRESS.

These notes are taken from the Technical Supplement to the Review of the Foreign Press issued by the General Staff of the War Office.—ED.

New Concrete Water-Towers.—During the war several concrete water-towers were built in Germany. One is the Water and Outlook Tower of the town of Schildberg, in Posen, from a design of Klein and Wolff, architects at Breslau. A tank of 250 cu. metres capacity free, i.e., without connection with the sustaining structure, rests on a floor of reinforced concrete borne by eight pillars of reinforced concrete joined by thin ornamental walls. The winding stairs are of moulded blocks made to represent stone. At the top cornice level is a circular outlook gallery. The cost of the tower was Mk.70,000.

Another structure for a similar purpose, exhibiting wealth of designing power, is a water-tower for industrial works in Upper Silesia. The tank, which has a capacity of 2,000 cu. metres, is 31 metres above the ground level. Below this tank is another of 150 metres capacity for drinking water. And on the ground level is yet another of the same capacity for ozonising purposes. Difficulties with the foundations made it necessary to excavate down to the firm rock, and to fill the excavation with 1 to 12 concrete. Here again the main tank is independent of the supporting structure. It is constructed of an inner portion of strong cement 4 centimetres thick. It is carried on concrete pillars bound together at intervals. The total cost of this structure, which is shown in elevation, was Mk.300,000.—*Journal für Gasbeleuchtung*, April 5th, 1919.

Diving Bell for Building Quay Walls.—The bell used for the Central Harbour at Gothenburg consists of an airtight chamber, 32 ft. 10 in. long by 24 ft. 8 in. wide, suspended from an overhead travelling crane with longitudinal and transverse travel. It is supported from rails resting on piles driven along the quay wall and securely held in position by diagonal struts, as cross ties would have interfered with the working of the bell.

It is provided with two air-locks, one for workmen, and the other for materials, the air chamber is 11 ft. 6 in. high, arranged for water ballast tanks on top. To sink the bell, water is pumped in by a 4 in. electrically driven centrifugal pump. The maximum air pressure used is 21·3 lb. per sq. in. above atmosphere equivalent to 50 ft. of water.

The quantity of water in the tanks is regulated by the air pressure through a special valve which permits surplus water to overflow and adjusts the total weight of the diving bell to the depth of immersion.

Compressed air is supplied by a blowing engine erected on the top of the diving bell and driven by a 6 h.p. electric motor. It is capable of delivering 350 cu. ft. of free air per minute at a pressure of 21·5 lb. per sq. in.

The lower edge of the diving bell can be raised 5 ft. above water level in order to be quite clear of the quay wall which is a shell of reinforced concrete with a heavy top and suitable partition walls. It is constructed in length of 164 ft., which are completed in two weeks, the wooden moulds being fixed the first week, and the concrete cast the second week. The whole of the work is executed under compressed air, the diving bell being raised as the work proceeds vertically. (*Teknisk Tidskrift*, April 16th, 1919.)

German Regulations for Reinforced Concrete Roofs.—The regulations of November, 1918, refer to flat roofs, stipulating the composition of the concrete, strength, and bending moment of slabs.

The maximum span is limited to 21 ft. 4 in., with a minimum thickness of 4 in. for loaded roofs, and 2⅜ in. for unloaded roofs. Additional thickness must be provided when subject to vibrations.

The rules refer only to reinforced flat roofs, but special rules are given for plain concrete slabs intended for roofs of dwelling-houses and factories.

Tests must be carried out under Government supervision. (*Beton u. Eisen* March 5th, 1919.)

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Houses and Roads.—A paper on the products of limestone by Mr. William Alden Brown was submitted to the South Wales Institute of Engineers at a recent meeting of that society at Swansea, under the presidency of Mr. Edward Dawson.

The author, remarking that the greatest building era ever known was coming on apace, strongly advocated concrete houses and concrete roads. He said that on the plea of expediency there was a great danger of houses being thrown up by the "jerry" builder, and the dreams and plans for a constructive housing scheme along permanent lines would fall far short of realisation. Brick and building stone were both expensive, and might be hard to get. Concrete was the one material which must be taken advantage of. Many business men had realised the possibilities of concrete for factories and warehouses, but they had been slow to take advantage of it for the erection of residences.

As to roads, Mr. Brown urged that water-bound macadam and gravel roads were obsolete. Experience in several countries demonstrated that a concrete road properly laid required practically no maintenance cost—repair expense. The actual figures show an expense of only £1 or £2 a mile a year. Articles of production must be vastly increased in the future if this country was to bear its burden of taxation. This could be done by keeping clear the lines of communication on our highways, facilitating transport and linking up our industries. Concrete roads were increasing the efficiency of every form of road locomotion. Motor trucks and horses could go faster, farther, and with less effort over concrete than any other kind of road. Concrete was helping the farmer by assisting him to haul two loads at one trip instead of one load at two trips. It either doubled the size of the load or cut in two the tractive power necessary to transport farm produce. With less capital tied up in horses, there was more cash to put into other equipment to increase the revenue.

Concrete Houses.—The following is an extract from a letter by Major-General A. S. Collard, which recently appeared in the *Times*. As our readers know, Major-General Collard was responsible, as Director of Inland Waterways and Docks, for much of the constructional work carried out for the Government during the war :—

"Good, dry, sanitary cottages, architecturally correct and pleasing to the eye, can be built with concrete blocks both cheaply and quickly if the proper methods are employed. Crayford Garden Village is an example, and only recently one of the *Times* special correspondents wrote in an article on Chepstow : 'Whatever may be the fate of the National Shipyards, the Government will be able to point with pride to the garden cities they are erecting there.' These houses are certainly picturesque, and are excellent examples of what can be done to meet the present demand for healthier homes for the workers. And the reason is, that in these cottages concrete has been used properly and scientifically. The outer walls are all hollow, with a proper space between each leaf, and care has been taken to see that there is no connection between these leaves at the door openings, etc., and the concrete is also of the right texture. It must be remembered that the secret in producing a good block for house building is to make it properly, and make it of concrete that is only just moist ; a block made of wet concrete will never be satisfactory. The blocks for these houses are being made with ' Winget ' machines, which seem to produce exactly what is required.

" Modern cottages built as I have described are as comfortable as any other houses, and a great deal more satisfactory from the point of view of health. Concrete blocks of the right consistency, with a continuous cavity, give a dry building with no chance of condensation, and remove all the old objections to concrete construction.

" The advantages of concrete block construction are many and varied. The blocks are larger than bricks and can therefore be laid quicker, there are fewer joints, and therefore less mortar, which both mean less cost. On many sides suitable aggregates can be found close at hand. This means no rail transport, whereas bricks have nearly always to be brought a considerable distance by rail, which in these days of rail congestion is a great point in favour of concrete blocks made with local aggregate. The blocks will always work out cheaper, except where bricks are made in the immediate locality, but where very considerable saving can be effected is in the employment of waste materials, such as clinker, slag, and sagger. The former is ideal for the inner leaves and internal walls of cottages, and can be used for the outer leaves in houses that are to be rendered or rough-cast. To-day some of the large gas companies have to pay for the removal of their clinker. What could, therefore, be cheaper than to employ it for making blocks for houses every one needs ?

" Another advantage the concrete block has is that any one can make it under proper supervision, and the blocks can be used soon after they are made. At the present time we are short of skilled brickmakers. Why not, therefore, I ask, employ the demobilised soldier on making blocks to make up the deficiency ?

" There is no reason why the exterior of houses and cottages built with concrete blocks should not be varied just as much as brick ones. Many architects object to concrete as giving a cold effect, but this applies equally to certain kinds of stone, and can be remedied by architectural treatment. The elevation of houses can be wholly ' rough-cast,' or bricks can be used for the outer leaf of the lower storeys only, and the upper portion ' rough-cast.' Where an all-brick face is required, the outer leaf can be built of brick and the inner leaf and the internal or partition walls of concrete blocks and slabs.

" Cottages built of concrete blocks surpass all ordinary types of construction for cleanliness and all hygienic conditions, as well as for durability and rapidity of construction, and they are more economical to build ; but let me repeat, the blocks must be made in the proper way and the construction details must be correct. When this is done success is assured."

Reinforced Concrete Roads.—A series of road-making experiments are being carried out in the south of England with reinforced concrete as the material, and results are awaited with great interest. The work is under the direction of the Essex County Surveyor, Mr. P. J. Sheldon, on a strip of road between Bishopscourt and the village of Springfield on the main road between Chelmsford and Colchester. A length of about 50 yards is being utilised. The old metal has been excavated to a depth of about a foot, two separate layers of concrete are being put down, and between them is a steel mesh which has the effect of binding and strengthening the whole. When complete the surface will be tar-sprayed and covered with light shingle. If this method proves successful, Mr. Sheldon intends to adopt reinforced concrete to a considerable extent, particularly for the great arterial highways leading out of London. Wood blocks and stone setts are not easily obtainable, and this is one of the reasons for the experiment, the cost of which is being defrayed from a grant made by the Road Board.

Concrete Structures to Lift Sunken Ships.—We learn from the daily press that for the past 18 months there have been arising on the Southwick side of Shoreham Harbour large structures of concrete and iron. From a forest of spars and girders there have now emerged two grey concrete objects—each a tower and platform on an elliptical base. They are, it appears, to raise the sunken ships with which the narrow seas abound. These structures are really concrete shells. They are to be towed to sea and submerged, so as to descend on each side of a sunken vessel. They are then to be firmly attached to the vessel by divers. The water in them will be pumped out, with the result, it is believed, that the two structures and the vessel between them will rise to the surface.

Concrete v. Timber.—Instead of buying timber, the Croydon Corporation is making concrete posts, at a saving of 9s. or 10s. on each.

The British Fire Prevention Committee are now issuing to the members a number of reports dealing with the fire resistance of reinforced concrete, as demonstrated in actual fires, the issue of which had to be delayed in several cases owing to the War Emergency.

Only a very limited number of these reports are available for non-members, and these are only obtainable upon written application to the Registrar of the Committee at 8 Waterloo Place, Pall Mall, London, S.W.1, the reports not being published in the ordinary way.

The reports, known as "Red Books," are the following, and their cost (post free) is mentioned in each case :—

No. 204. "The Fire at the Edison Phonograph Works, New Jersey, U.S.A., of December, 1914." By F. J. T. Stewart. 3s. 6d.

No. 207. "The Fire Resistance of Reinforced Concrete as demonstrated at the Edison Phonograph Works, New Jersey, U.S.A., during the fire of December, 1914." 5s.

No. 208. "The Fire at the Millennium Mills, Victoria Docks, Silvertown, London, on January 19th, 1917." By Ellis Marsland. 5s.

No. 214. "Fire in a Reinforced Concrete Warehouse at Far Rockaway, New York, U.S.A." By Ira H. Woolson. 2s. 6d.

No. 225. "The Fire at the Quaker Oats Company's Premises at Peterboro', Ontario, Canada, on December 11th, 1916," being two Reports, Part I. by A. J. Mylrea and Part II. by T. D. Mylrea. 4s.

The Concrete Block Industry and City Supervision in U.S.A.—In many cities in America the concrete block industry is now under the inspection of the city building inspectors, with the result that a high standard of block making is reached, and there is an increased demand for, and confidence in, concrete blocks for building purposes. This supervision is due to the fact that some time ago, concrete blocks were, in many cases, being badly made, with a result that the industry as a whole suffered.

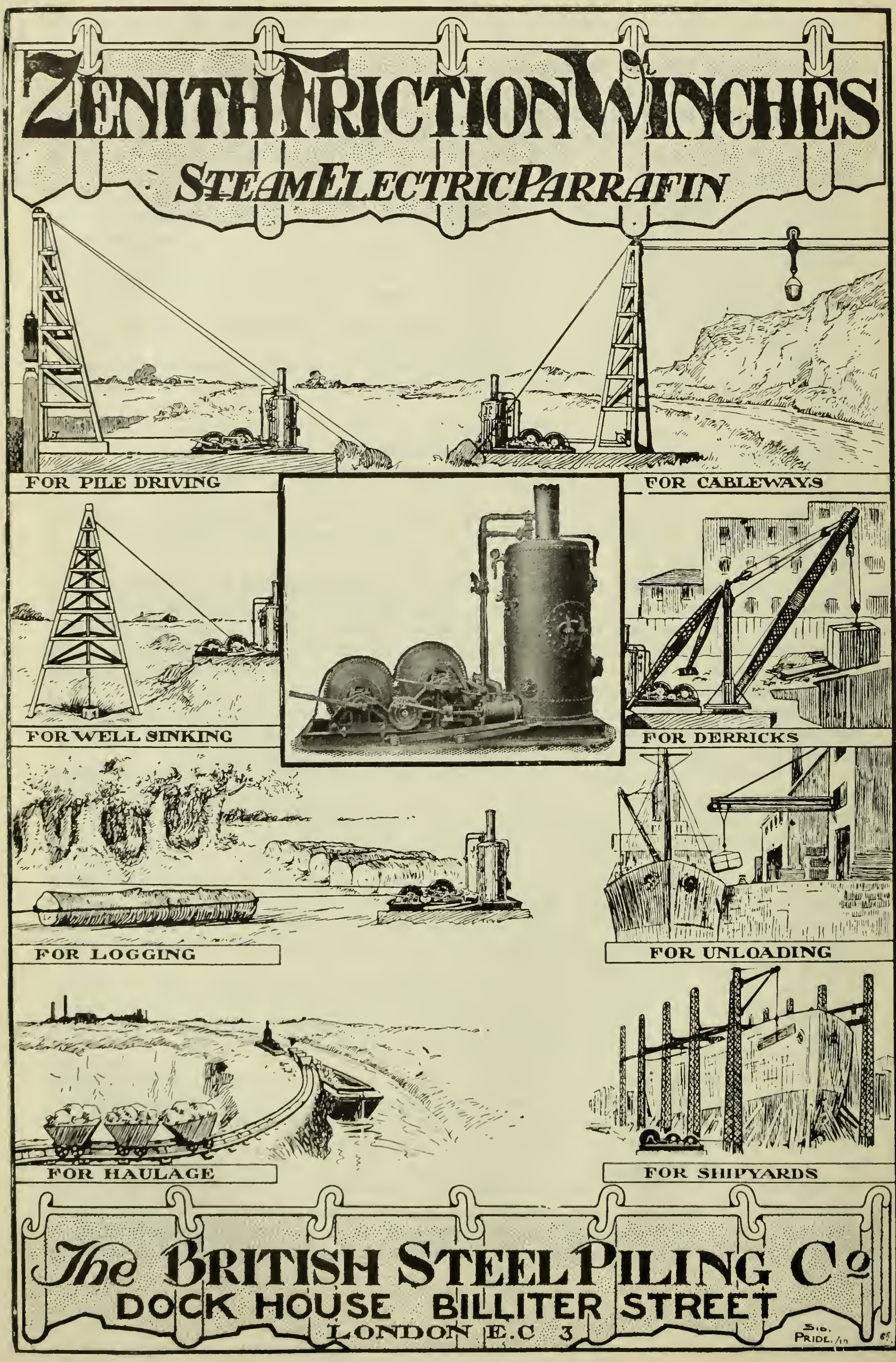
All concrete block factories in such cities where supervision has been inaugurated are periodically inspected by the building inspector, who makes his own records of the method of manufacture at each plant, kinds of aggregate used, etc.

In Cleveland, one of the first cities where concrete blocks were recognised under the building code, the code requires that every manufacturer's block must stand a favourable test, at least once in six months. The strength requirement is 1,200 lb. average compressive strength on net area, and 800 lb. minimum for any block ; the absorption, 6 per cent. average—no exception exceeding 9 per cent. If a manufacturer is experiencing some trouble in reaching the demanded standard, or is experimenting with a new aggregate, the inspector goes down to the works and renders all available assistance. If a maker's blocks do not reach the given standard he is afforded every opportunity to improve them. A new mix or a different aggregate are recommended, and a second test made, and sometimes a third.

The manufacturers are, by this combination of supervision and assistance rendered by the city, induced to keep themselves informed of every new idea and to turn out a good block. It is stated that this supervision has helped the concrete block manufacturer and instigated progress in the industry.

Concrete Bricks.—A firm in Caldwell, Idaho, U.S.A., are turning out some very good concrete bricks for building purposes by means of a special press. They are succeeding in getting various colours and textures, and these bricks are being used to a considerable extent for various types of buildings.

Good Works Certificates.—In the May issue of the Journal of the Royal Institute of British Architects Mr. J. H. Kerner-Greenwood makes some useful and interesting comments on a suggestion put forward in a previous issue by Mr. S. B. Caulfield that the R.I.B.A. found an association for tradesmen, to be nominated by a number of architects under whom they had worked. Mr. Greenwood says if one of the Institute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architects was pleased with the way a builder had carried out his ideas, it should not be a very difficult matter for the architect to call in two of the members of the Institute to verify that the Institute's certificate was worthily earned by the builder. There would be keen competition amongst builders to hold these certificates, for they would form a visible standard of quality, which no builder at present can possess or attain. All builders would desire this recommendation and proof of their reliability, and it would be an incentive to them to put the best materials and labour into all their constructional work. Further, there seems no reason why artisans themselves should not obtain a similar certificate, for when a joiner, bricklayer, plumber or mason has done some difficult or intricate work, it would certainly give that impetus to craftsmanship which nearly all architects are agreed is sadly wanting.

The Society of Engineers (Inc.).—Association and co-operation are the order of the day, and the Council of this Society, having realised this, have prepared a scheme for the Association of Engineering Societies, of which a few particulars are given herewith. The Gloucestershire Engineering Society was the first to be associated with the scheme.

The Society shall, subject to compliance with its Articles of Association and By-laws, admit to membership, corporate or non-corporate, any duly qualified member of any Associated Society.

All members of Associated Societies shall be entitled to the following privileges: (*a*) To attend the ordinary meetings, visits and social functions of the Society; (*b*) to make use of the library and reading room of the Society; (*c*) to make use of the appointments and employments registers of the Society; (*d*) to compete for such premiums as may be awarded by the Society in open competition.

For full particulars apply to The Secretary, The Society of Engineers (Inc.), 17, Victoria Street, S.W.1.

PUBLICATIONS RECEIVED.

Béton Armé.—The Belgian concrete journal for May contains articles dealing with the Belgian Cement industry, the construction of reinforced concrete walls, and the question of concrete roads.

TRADE NOTES.

Flooring in Houses.—The National Housing Council advise that an impervious layer should be placed under all floors to save the health of the inhabitants.

A perfectly moisture-proof covering is obtained at a minimum of cost by rendering or floating a 1-in. waterproofed cement mortar over a concrete, which may be mixed as weak as 6, 3, 1. The Pudloed coating should be coved where it meets the walls to prevent the access through the joints of both vapours and vermin.

Messrs. Stevens & Co., the proprietors of "Torbay Paint," of 26–28, Billiter Street, E.C., have, we learn, undertaken the management of a new company formed to place the following water-proofing and other specialities on the market:—(1) "Novoid," a composition in powder form, which, it is claimed, when added to the cement and aggregate used in the production of concrete, increases the strength of concrete, and renders the entire mass water, acid and oil proof; (2) "Roxet," a colourless solution for coating existing cement, concrete, stucco, etc., and rendering the surface impervious to water; (3) "Rencrete," a liquid solution similar to "Roxet," but carrying colour in a variety of shades; (4) "Quelle," a preservative and insect-rot-weatherproof stain, which, we are informed, renders timber fire-resisting and,

MISCELLANEOUS.

Rate —6 lines (or under), 5s.: each additional line, 10d. Remit with order.

ASSISTANT Mechanical Engineers required for Cement Company in Hongkong, age 25/30, single, well-educated. Applicants must have practical and technical training and mill work experience. Three years' agreement.— Apply Box 976, Leathwait & Simmons, 5 Birchin Lane, E.C.3.

beyond charring, impervious to flame. Green timber treated with "Quelle" will not absorb moisture, shrink or swell.

A practical demonstration of the above specialities was recently given to a number of architects and engineers.

Concrete Making with Up-to-Date Machinery.—A pamphlet under this title has just been published by Mr. O. M. Rikof, proprietor of the Perfect Concrete Mixer Co. The first chapter in the booklet gives Hints on Concrete Making, and deals fully with the question of hand-gauged and machine-mixed concrete—and the necessity of the cleanliness of the materials used for making concrete. The author then goes on to give a description with illustrations of the "Perfect" concrete gauging and mixing machine.

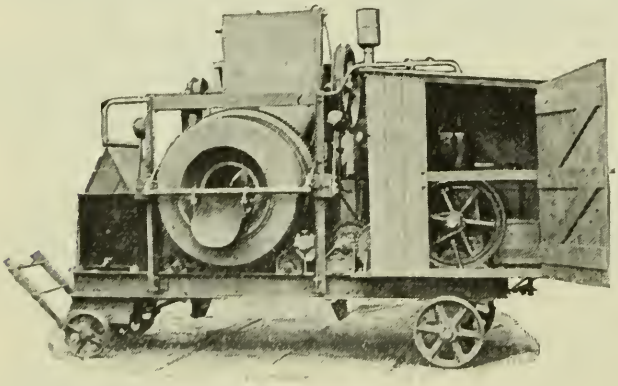
Briefly stated, the machine is provided with an automatic gauging and feeding device for each separate material to be used in the concrete, and is designed on the principle of continuous working.

The "Complete" sand and gravel washer, another appliance supplied by the above company, is then dealt with at length.

The booklet contains some very good illustrations, and is well got up. General instructions are also given for erecting the machinery supplied by the company. The price of this publication is given as 3s. 6d., but it can be had free on application to the Perfect Concrete Mixer Co., Broxbourne.

PERSONAL.

Mr. T. B. Shore, who has been manager and director of the Considere Construction Co., Ltd., since its formation in 1908, has severed his connection with that company and has joined the board of Sir William Arrol & Co., Ltd., as the director responsible for their reinforced concrete department. It is the intention of Sir William Arrol & Co., Ltd., to extend and develop their business in the design of reinforced concrete work in all its branches, and to extend the outside construction organisation. Mr. Shore will control and be responsible for this department of Messrs. Arrol's business.



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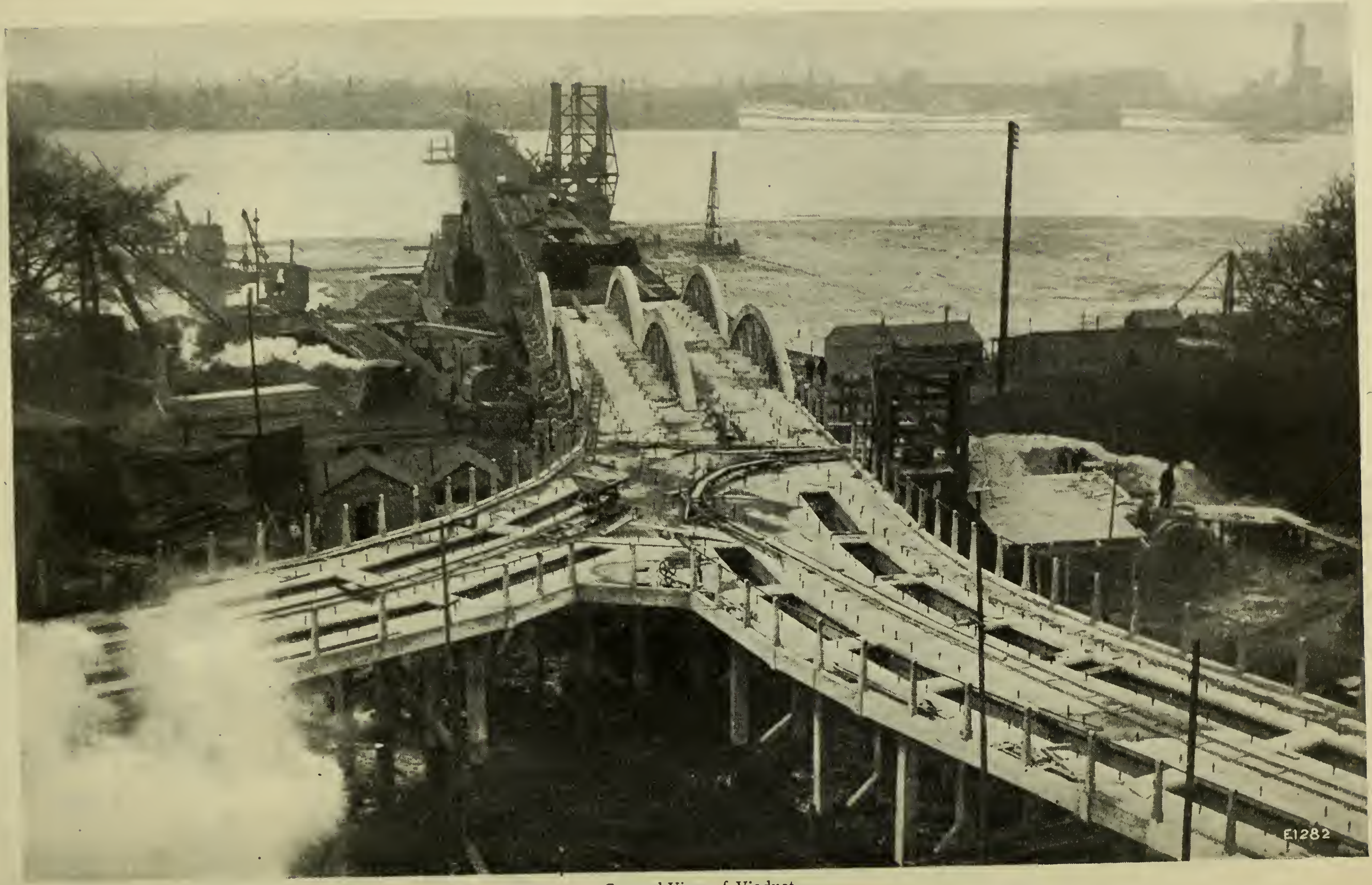


General View of Viaduct.
Government Rolling Mills, Southampton.
*(See **page** 409.)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 8. LONDON, AUGUST, 1919.

EDITORIAL NOTES.

HOMES FOR THE PEOPLE."

Two interesting articles under this heading appeared in recent issues of *The Builder*, and they cover so many important points that we have reproduced the greater part of the text in this issue. We have continually dealt with the Housing Question in these notes, but the matter is of such urgency and importance that continual reference is justified, and in fact appears to be very necessary, because no real progress is being made in the erection of suitable houses. The delay in proceeding with the erection of a large number of dwellings is due to several causes, among which are the shortage of labour and material, the high cost of building work, and the difficulty of moving quickly in any enterprise wherein Government regulations and officials are encountered with the inevitable " red tape."

The shortage of labour and material is more assumed than real because the problem is being considered without due regard to the possibilities of machinery and modern methods of construction. The author of the article above mentioned puts forward a very strong case for the extensive use of labour-saving plant and pre-cast concrete units, and his suggestions are worthy of serious consideration by the interested parties. There is no doubt that the average British contractor is too conservative to make such rapid progress in the development of the use of labour-saving machinery as the American builder, and the broader outlook of the latter has led to the extensive adoption of machinery for mixing and placing concrete which enables him to execute a large quantity of work in a very short time. As evidence of this it will be seen that the majority of the mixers and block making machines recommended by the author are of the American type, while the organisation generally, and methods of transporting and depositing the concrete are equally developed to give speedy execution in America. It must be borne in mind that a considerable number of American homes are still being erected with timber framing owing to the large quantities of this material which are available, and such structures are cheap and can be quickly built. Concrete has therefore had to contend with a very serious rival in America, and this is probably the reason for the evolution of concrete making machinery which will give quick results at low cost ; but the conditions in this country also call for the adoption of methods which will reduce the cost of building work to the minimum and allow the required dwellings to be erected in a short time. Thus a good opening is provided for the enterprising builder who will take advantage of the most modern methods in the execution of his work. Labour is certainly not so plentiful as it was in pre-war days, and it therefore becomes essential to reduce the amount required to the absolute minimum. It is here that machinery will be useful.

It is still quite a common occurrence in this country to see comparatively large contracts wherein the concrete is mixed by hand, and this is almost inconceivable when it is realised that better, quicker and cheaper work can be produced by the use of a concrete mixer. This is one instance only, and similar principles apply to the handling of large quantities of raw materials and transport of the mixed concrete to the place of casting.

As regards the shortage of materials, we are not bound to use bricks, as many persons apparently still maintain, and the shortage cannot be considered to be real until all our resources have been taken into account. There is no shortage in the facilities for the manufacture of Portland cement, and suitable aggregates abound in almost all localities, but there appears to be a tendency to overlook these facts, and the parties responsible for the new housing schemes are not sufficiently progressive to adopt modern materials and methods in order to give the accommodation which is so badly needed. There is undoubtedly a shortage of bricks, they are excessively high in price and expensive to lay, owing to the high rate of wages and the greatly reduced output of each bricklayer, and yet the material is still advocated and adopted for many schemes when concrete could be economically employed. The author gives a comparison between Brighton and Luton, where the former proposes to spend £900 per house and the latter, by the adoption of concrete, can build for £350 per house. Surely it does not require many instances of this kind to convince even the most sceptical person that full advantage should be taken of concrete construction if quick and economical work is to be obtained. During a recent visit to the United States we were impressed by the real progress that is being made in the provision of dwellings of all classes to make up the deficiency that now exists. The shortage there is as serious, owing to war conditions, as it is in this country, but a good start has already been made and numerous houses are being erected in practically all the States. Advantage is being taken of all the material available, and structures of timber, concrete and brick can be seen in the course of erection in the same locality, and no effort is being spared to get the buildings up quickly. Timber cannot be extensively used in this country as it is not plentiful, is comparatively costly, and at the same time it is not so desirable for permanent structures. Bricks are available in limited quantities, and these should be used in conjunction with concrete, or in those districts where they are produced and when good aggregate is not readily obtainable, but concrete is undoubtedly the one material upon which we can depend to provide the carcase work for the majority of the 300,000 homes. Postponement and delay are fatal because prices will not be reduced to any extent in the near future, if they are reduced at all, and instead of attempting to curtail expenditure by reduction of sizes and accommodation generally an effort should be made to organise the work and use machinery and available materials in the best manner in order to prevent unnecessary expense. The chief point is the urgent need for numerous dwellings, and it is the worst possible policy which allows any scheme to be delayed because old-fashioned materials and methods cannot be adopted, and those materials which are available are not used because some persons are not quite conversant with their possibilities and uses.

REINFORCED CONCRETE WORK AT GOVERNMENT ROLLING MILLS, WOOLSTON, NEAR SOUTHAMPTON.

For the following particulars and illustrations we are indebted to Dr. Oscar Faber, O.B.E.—ED.

In connection with the Rolling Mills at Woolston, erected by the Ministry of Munitions, a large amount of reinforced concrete work was employed, some of which is sufficiently interesting to justify a short description.

The more important of these works were the reinforced concrete bridges and viaduct, the power house raft, the coal and coke bunkers, and the water tower.

Fig. 1 shows the lay-out of the viaduct and the position of the two bridges, and also shows the beginning of the single line sidings, which is constructed to a slope and eventually comes down to ground level. The holes in the deck are constructed so that coal wagons, arranged with a hopper mouth arrangement underneath, can discharge coal anywhere along the viaduct and so form a very large storage space, from which it can later be collected by means of a travelling jib crane running round on the viaduct and picking it up from the two sides.

Expansion joints are provided at every 100 feet approximately.

Fig. 2 shows the general construction of the viaduct to a larger scale. It will be noticed that a continuous foundation was provided for the four columns forming each trestle, and that each trestle was braced by a diagonal brace transversely. In regard to the longitudinal bracing the viaduct is divided up into five spans to each section between expansion joints, and in general the centre span is braced longitudinally so as to allow the end spans to expand or contract with the temperature variations.

The transverse braces are designed for the worst combination of winds, including wind on the trucks and locos, and of the centrifugal force of trains running round curves, and the longitudinal braces are designed for wind and for stresses set up by a train travelling at speed suddenly applying the brakes.

The sleepers generally consisted of longitudinal sleepers bolted to the longitudinal beams, and the hand-rail of reinforced concrete posts fitted with gas barrel rails and intermediate wires.

Fig. 5 shows the construction of the sloping sidings, which is also constructed in sections of about 100 feet in length, separated by expansion joints, the central span only being braced longitudinally for the same reason as before, and a section of the trestle is shown with a brace transversely on each trestle.

Fig. 3 shows the arrangement of the bridges. These are of the bow string lattice girder type, three girders being provided to carry the two lines of rails, and the cross girders are continued out beyond the two outer main girders, so as

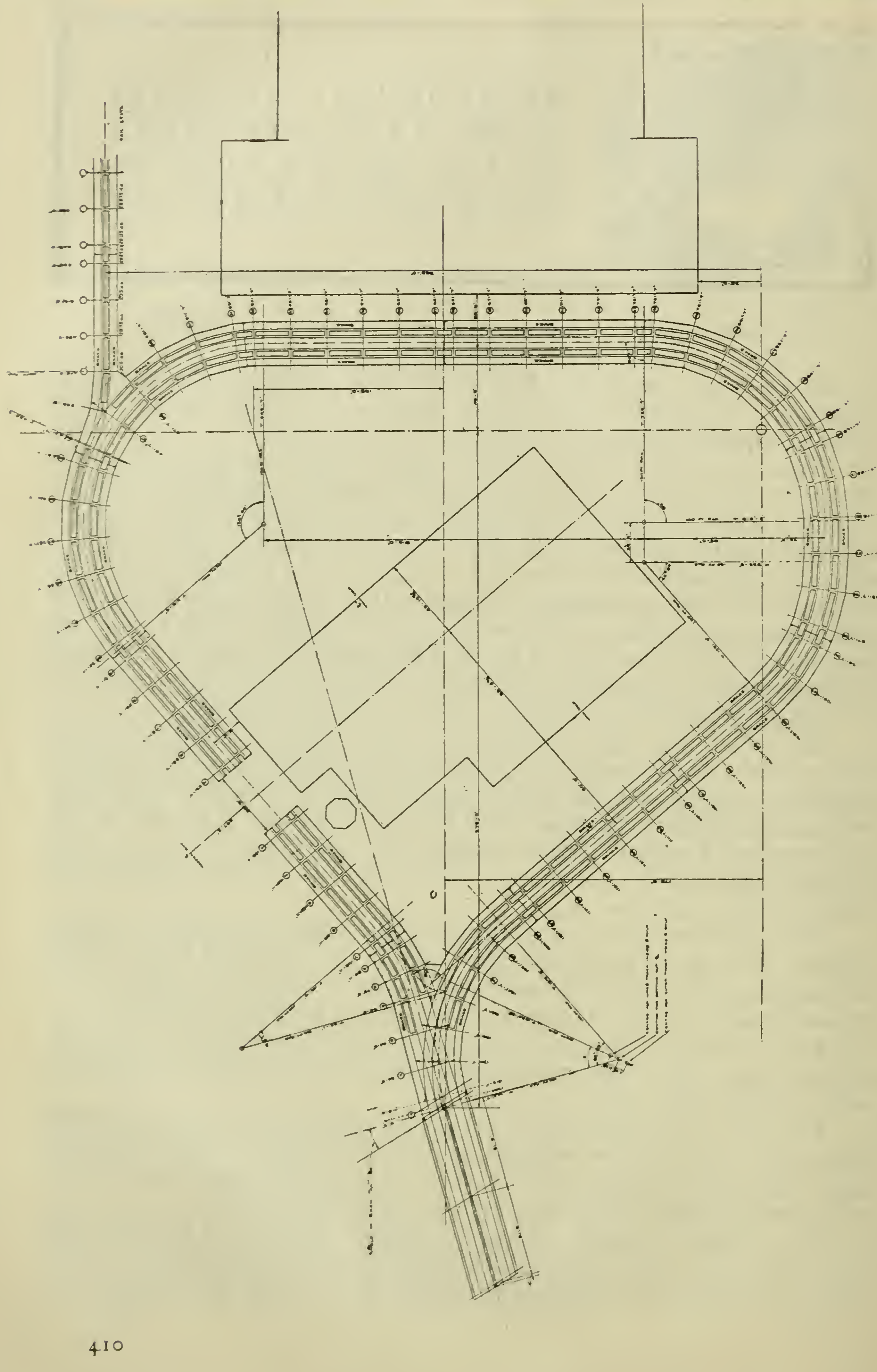


Fig. 1. Lay-out of Woolston Viaduct.

Reinforced Concrete Work at Government Rolling Mills, Woolston, near Southampton.

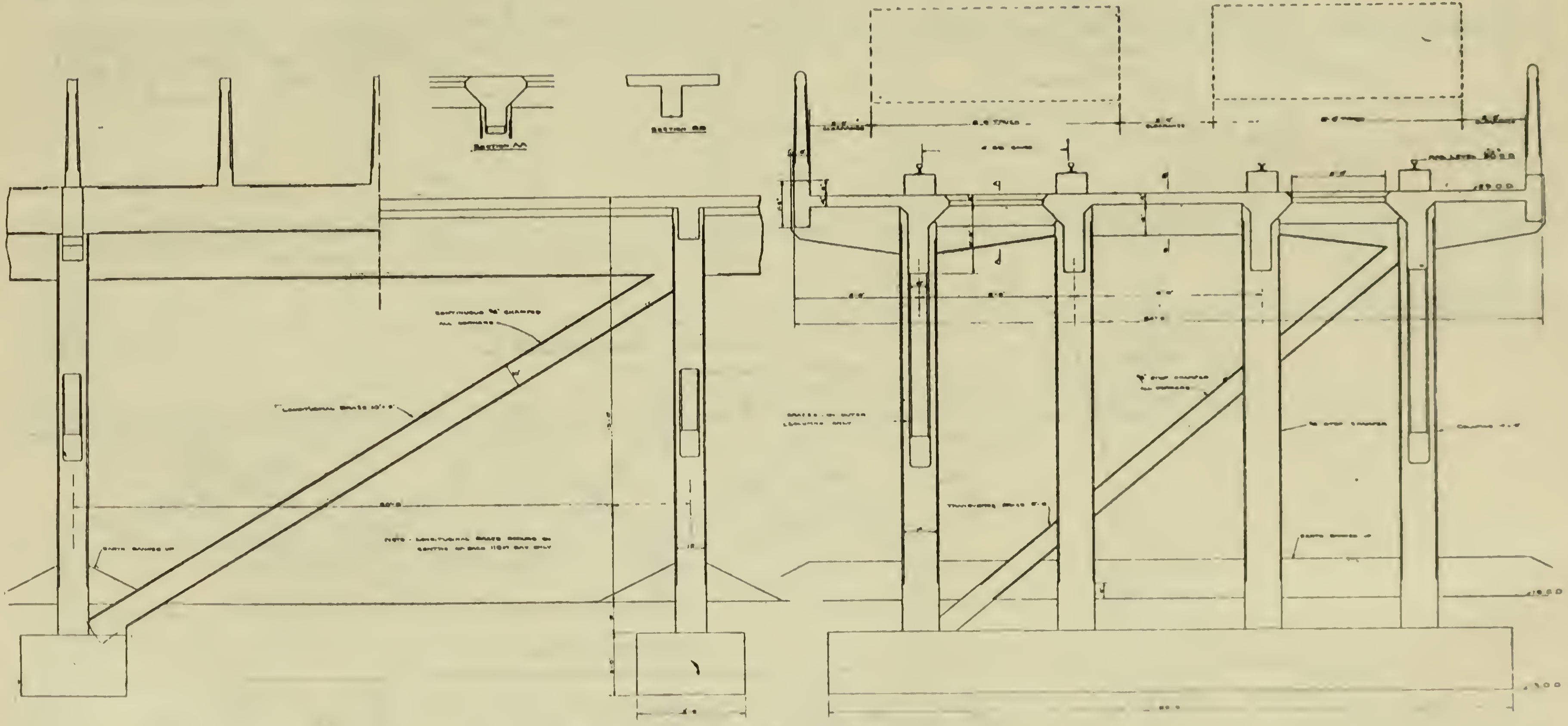


Fig. 2. Concrete Details of Woolston Viaduct.

Reinforced Concrete Work at Government Rolling Mills, Woolston, near Southampton.

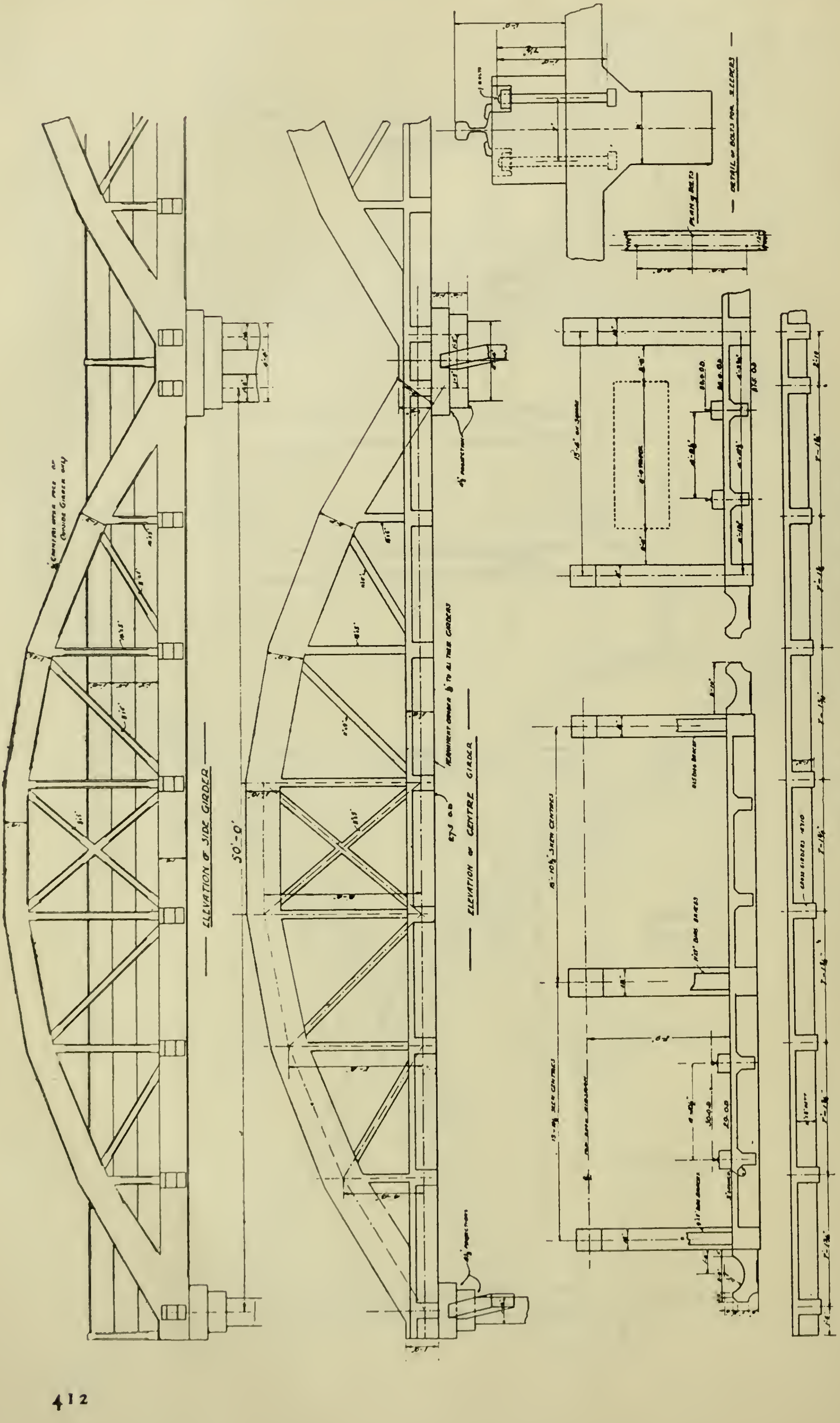


Fig. 3. Concrete details of Bridge Girders, **Woolston Viaduct.**
Reinforced Concrete Work at Government Rolling Mills, Woolston, near Southampton.

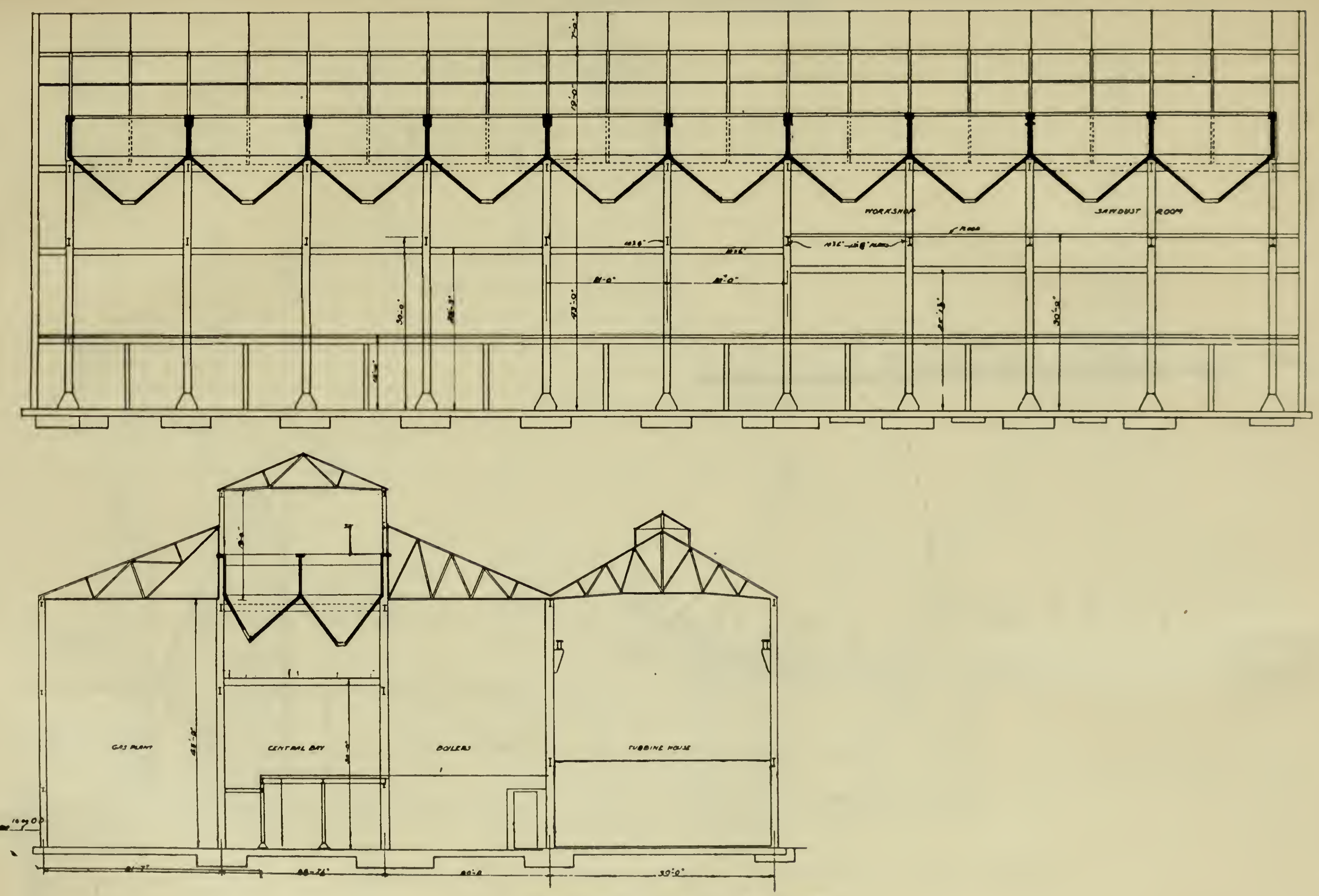


FIG. 4. Section through Power House—Bunkers.
REINFORCED CONCRETE WORK AT GOVERNMENT ROLLING MILLS, WOOLSTON, NEAR SOUTHAMPTON.

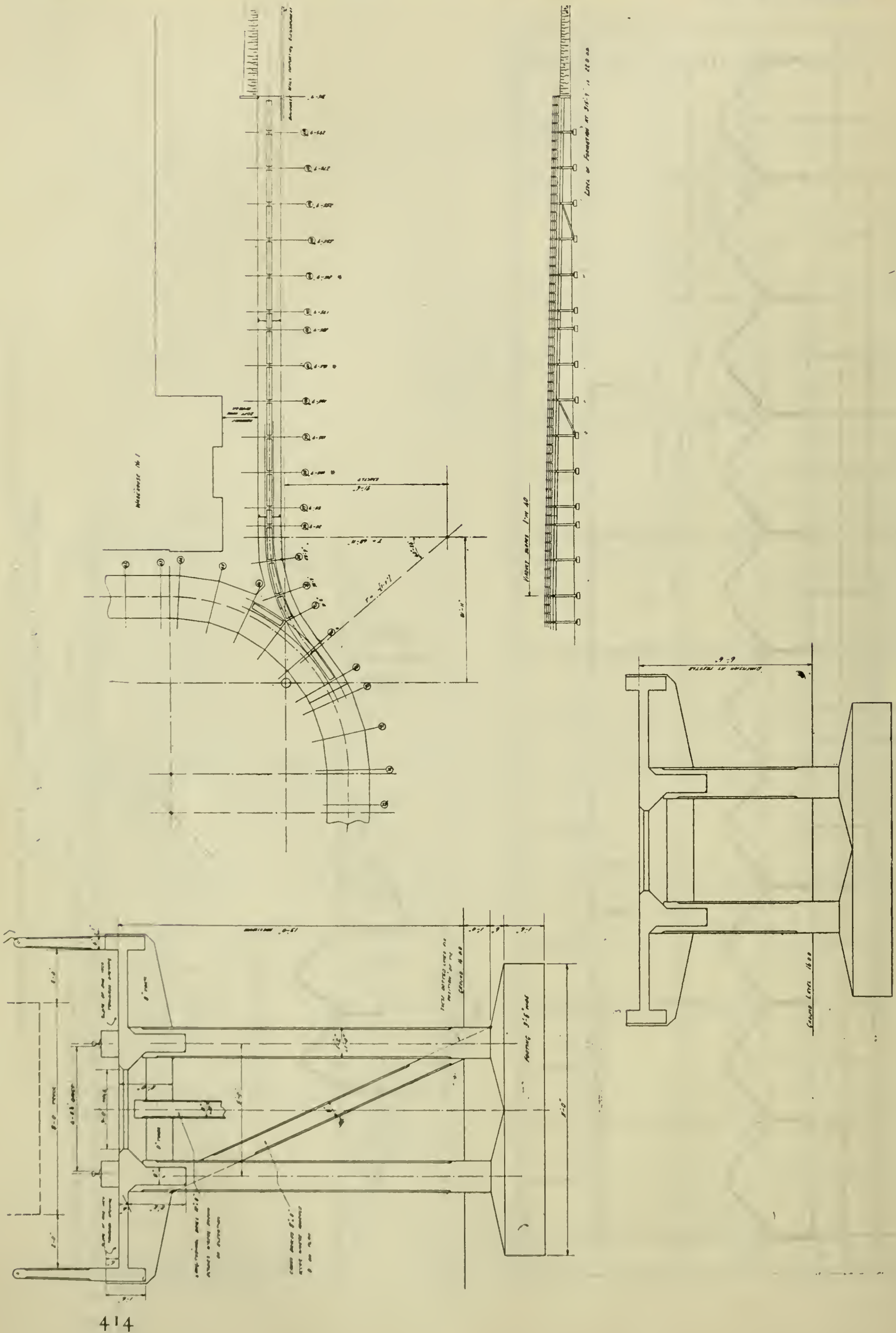


Fig. 5. Detail of Revised Siding of Viaduct.

Reinforced Concrete Work at Government Rolling Mills, Woolston, near Southampton.

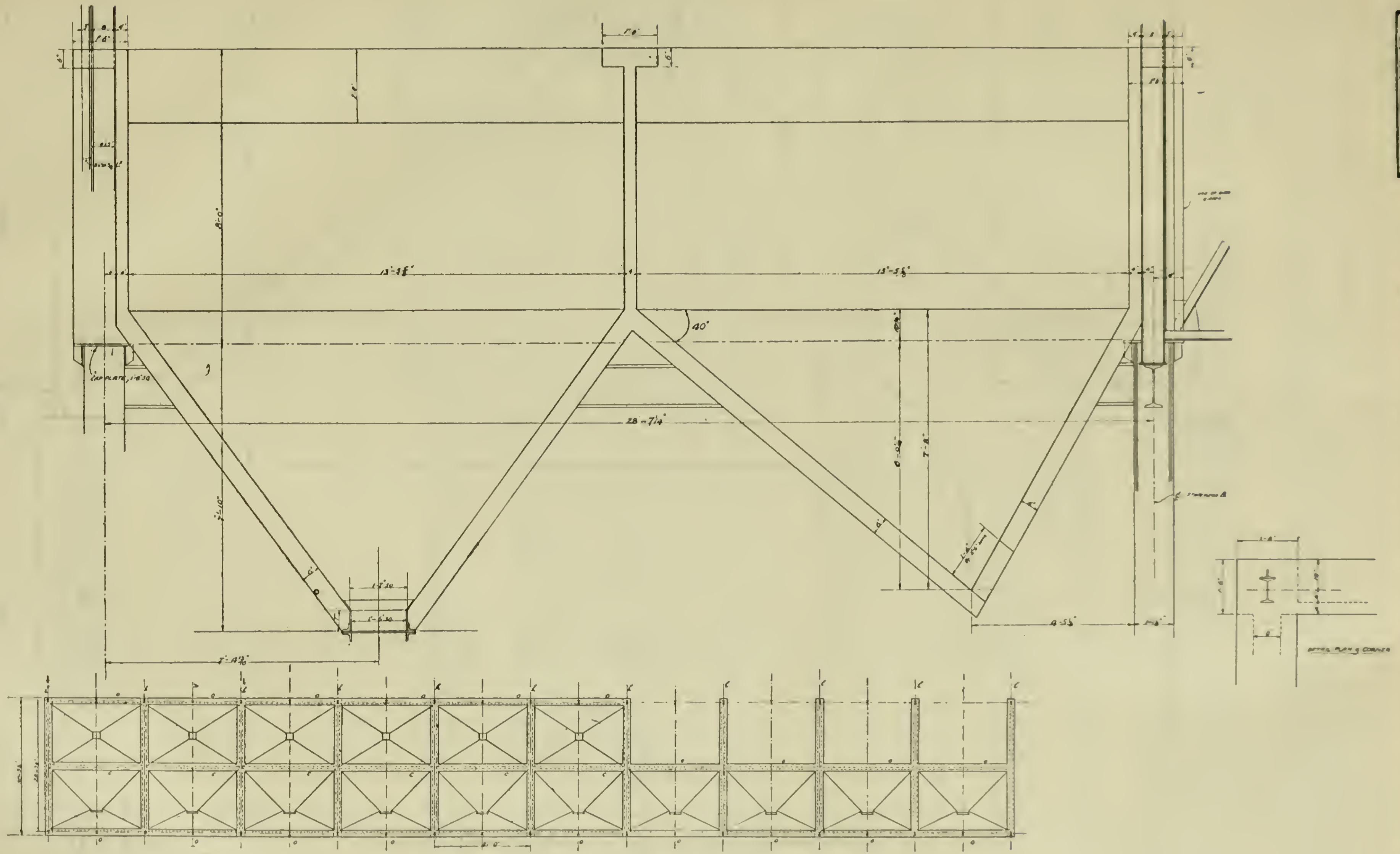


Fig. 6. Transverse Section—Details of Bunkers.

Reinforced Concrete Work at Government Rolling Mills, Woolston, near Southampton.

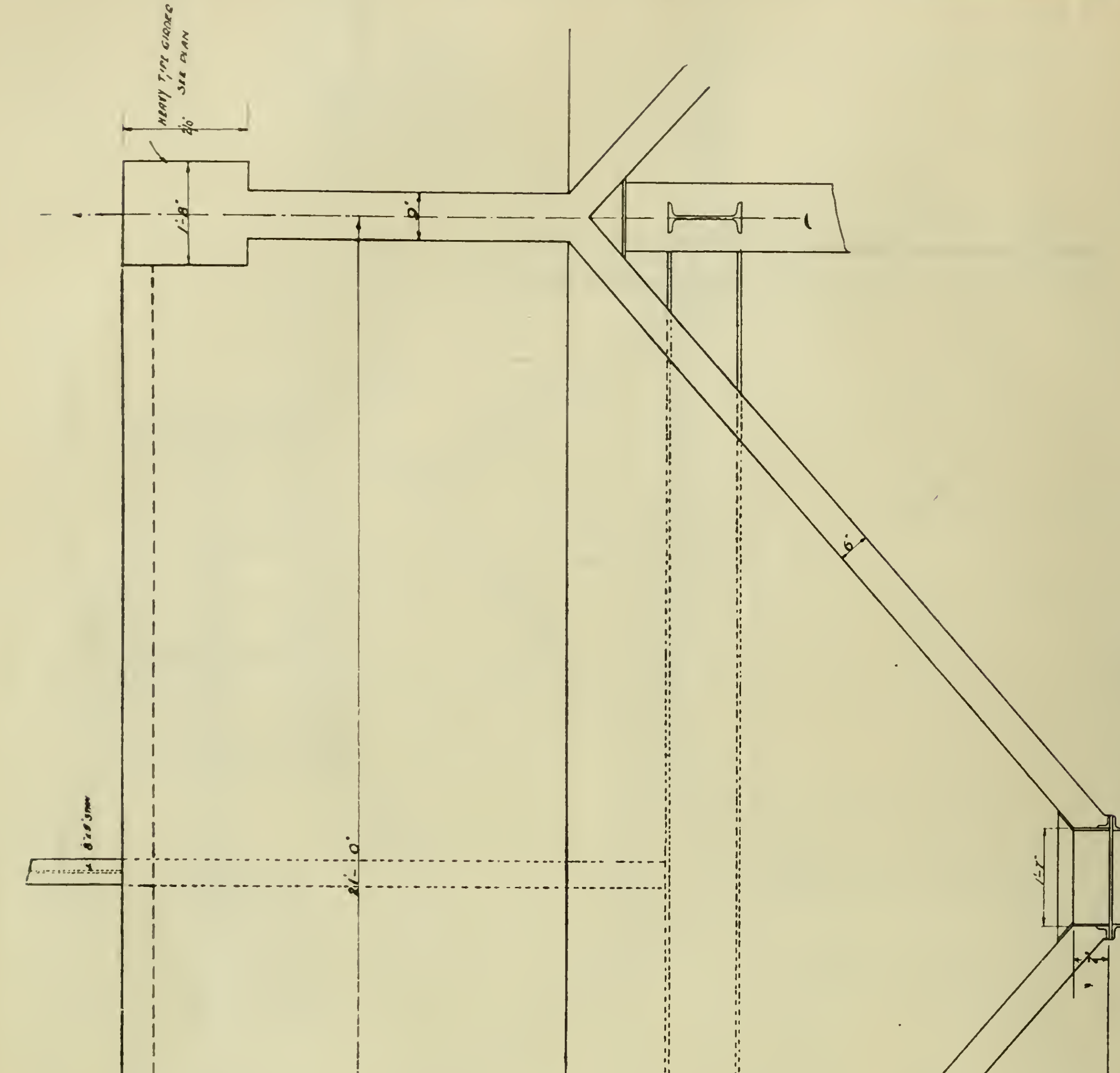


Fig. 7. Longitudinal Section of Coal Hoppers.
REINFORCED CONCRETE WORK AT GOVERNMENT ROLLING MILLS, WOOLSTON, NEAR SOUTHAMPTON.

to provide cantilever supports for two large pipes carrying the condensing water from the power house. It will be noticed that the thickness of the concrete decking is only 18 in., which was important at this place, where head room was very limited.

Coming now to the power house, which was a very large one, the whole of this was founded on soil which consisted alternatively of layers of clay and layers of peat, and therefore was a very bad subsoil to build an important power house on, particularly as this contained large turbine sets, where any want of alignment would have been particularly disastrous.

The whole of the site was therefore floated on a reinforced concrete raft which was thickened under the heaviest columns.

The power house is divided into four bays longitudinally, containing respectively the gas plant, the coal and coke bunkers, the boilers and turbine house.

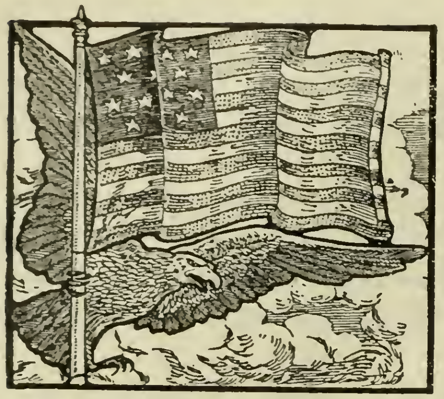
The coal bunkers are of reinforced concrete 210 ft. long and at a height of 50 ft. from the ground, and from the hopper mouth bottoms shoots deliver the material direct to the gas producers in the one bay and to the boilers in the other. The coke bunkers are particularly interesting as being of unsymmetrical design, where the calculation of stresses had to be made with more than ordinary care.

Along the top of the coal bunkers a reinforced concrete tank for holding the hot water was also constructed.

Fig. 6 is an enlarged view of the coal and coke bunkers. The interesting thing about these is that the dividing wall acts as a main girder and carries one coal bunker and one coke bunker across to the supports on a 28 ft. 7¼ in. span. This girder is shown in section in *Fig.* 7, and it will be appreciated that the load which it carries is very considerable. The reinforced concrete girders forming the walls of these coal bunkers also carry the intermediate roof stanchions.

The whole of the work was carried out under considerable difficulties in war time, notwithstanding which very considerable speed was secured, the reinforced concrete work being constructed by Messrs. Trollope & Colls, Ltd., of London, to the designs of Dr. Faber, O.B.E., D.Sc.

The whole layout of the works and so on was designed by J. M. Kennedy, Esq., O.B.E., who acted as engineer for the whole scheme and afterwards as Superintendent of the Rolling Mills.



THE AMERICAN SOCIETY FOR TESTING MATERIALS ANNUAL MEETING.

The American Society for Testing Materials held their annual meeting at the end of June, at Atlantic City, N.J. One of the special features of the meeting was the great expansion of co-operative work with other societies and with testing and research laboratories. From the papers read at the meeting it was evident that there is great activity in the United States in every branch of research relating to engineering work and building construction. It is not possible for us in this issue to present any of the papers read, as their full text has not reached us, but we feel our readers would probably be interested to know what is being done in this direction in America, and we therefore present below a short general account, leaving the publication of the papers which are of special interest to readers of this journal to subsequent issues. Our report is abstracted from a fuller report which appeared in "Engineering News-Record"—ED.

A NEW era in the life of the American Society for Testing Materials was inaugurated by the twenty-second annual meeting, held at the end of June, at Atlantic City, N.J The significant development of the meeting was great expansion of co-operative work with other societies and with testing and research laboratories. Renewal of vigour in materials study was apparent, not only in the unusually strong programme of papers presented, but also in announcements of work in progress or to be undertaken.

Notable technical work constituted the essence of the meeting Several new testing instruments gave further proof of the activity of laboratory investigators In cement and concrete, work of exceptional importance was brought to the fore A paper on paint tests brought new light to bear on this subject.

STANDARDISATION.

Various matters were dealt with under this heading, and dealing with the subject of international standardisation, a speaker asserted that "nothing will promote international trade co-operation and good fellowship so much as would the establishment of wise and mutually satisfactory standards," some of which, he said, are an international language, an international religion, the metric system, the centigrade thermometer scale, an international coinage system, and the like. Finally, he expressed hearty approval of a central standardising body, whether committee or association.

NEW TECHNICAL CO-OPERATIVE WORK.

It was announced that several important joint technical committees are in process of formation.

Reinforced Concrete.—Of widest interest, perhaps, is the case of the projected new joint committee on reinforced concrete. On the request of the society's committee C2 (reinforced concrete), the executive committee invited the American Society of Civil Engineers, the American Railway Engineering Association, the American Concrete Institute and the Portland Cement Association to join with the society in forming such a joint committee. To confer and arrange for organisation, .a special committee has been appointed.

Concrete Culvert Pipe.—On invitation of the American Concrete Pipe Association, the society has joined with it and with the American Concrete Institute, the American Association of State Highway Officials, the American Railway Engineering Association and the American Society of Civil Engineers, in establishing a joint committee to consider specifications for concrete culvert pipe.

Research Co-operation.—Representatives of the society have been appointed, on invitation, to the engineering division of the National Research Council and to the American Welding Society.

OTHER FEATURES OF COMMITTEE WORK.

A very simple colorimetric test for impurities in sand, for use in the field, was reported by the committee on concrete and concrete aggregates. It requires only a prescription bottle and some sodium hydroxide solution. For its application a colour chart will be issued later.

Compression tests for cement have been under consideration by the cement committee. While no action has been taken, it was stated to be probable that a compression test will be recommended by next year, as a substitute for the long-standard tension test for cement.

Two important recommendations by the Lime Committee involve broad interests. One took the form of a resolution asking that a standing committee on sand be appointed, to work with sand sub-committees of all technical committees whose field touches this important material. The other, expressed as a suggestion only, is that steps be taken by the society to endorse the standard sieves of the Bureau of Standards. In connection with this matter, joint committees on screens and on screen wire are under discussion.

TECHNICAL PAPERS ON TESTS AND MATERIALS.

The meeting was noteworthy for the number of strong technical papers presented.

Five new instruments and machines for testing were described, distinctly extending the range of tests available for study of materials. Of related character was the American Concrete Institute paper of F. R. McMillan, describing the recording extensometer used in the ship-stress studies of the Emergency Fleet Corporation, which paper was read at a joint session of the Institute with the society. The " strainagraph," as this instrument is called, has been applied with remarkable success to both concrete and steel ships, and through its use a greatly increased fund of data for ship design is being accumulated.

OBSERVATIONS AND DATA ON MATERIALS.

Research in materials was also represented prominently, various metals being dealt with as well as cement, concrete and refractory brick.

CEMENT AND CONCRETE PAPERS.

Proportioning concrete came in for a major part of the discussion in the concrete session. As a basis there were two papers, on " Proportioning of Pit-Run Gravel for Concrete," by R. W. Crum, and on " Theoretical Studies in Proportioning Concrete by the Method of Surface Areas," by R. B. Young. Mr. Crum's tests were made to determine a working basis for Iowa aggregate as used in highway work in that State. The method consists essentially in controlling the aggregate by the proportion of fine to coarse aggregate. Mr. Young reported the preliminary work of the Hydro-electric Commission of Ontario, which is placing many thousand yards of concrete. The tests are at present very extensive, and tend to prove the applicability of the surface-area method for practical work. The author contends, however, that the fineness-modulus method is only another means of determining the physical condition which surface area represents. In the discussion Professor Abrams disagreed to the extent of claiming that the surface-area method does not check the fineness-modulus method except when the material is uniformly graded.

G. M. Williams, of the Bureau of Standards, stated that, so far as their tests go, they were unable to check the fineness-modulus results with those by the surface-area method. He also stated that neither one appears to ensure concrete of known or uniform consistency, and therefore is not usable in laboratory comparison. Professor A. N. Talbot stated that the laboratory of the University of Illinois had been making a number of tests in an investigation of this matter, both with the surface-area and with the fineness-modulus methods. He said that these tests tended to show that strengths were dependent upon surface areas and that while both methods apparently have possibilities, at present he favoured a surface-modulus method which gives a relation to the surface area. In concluding, Professor Talbot said that a number of elements enter into the manufacture of concrete and that we cannot take any single one and say that it represents the distinguishing element in the properties of the material. L. N. Edwards, the propounder of the surface-area theory, also discussed the papers.

Another paper on concrete was a very extensive one on the modulus of elasticity of concrete by Stanton Walker. This gives the results of thousands of tests and establishes the relation between four different measures of the modulus of elasticity of concrete in more or less common use. A paper on methods of curing standard concrete specimens, by Howard W. Green, checks previous conclusions on this subject.

Cement fineness has been made the subject of an extensive series of tests at the Structural Materials Laboratory of Lewis Institute during the past year. The results of the tests, covering many pages, were reported in a paper by Professor Duff A. Abrams. Briefly, he experimented with seven different degrees of fineness varying from 2 per cent. residue on a 200-mesh sieve, to 43 per cent., and broke in compression some 6,000 6 in. by 12-in. cylinders, and in tension some 9,000 mortar specimens. He found that fineness increased strength in a straight-line ratio, the increase being about 2 per cent. (seven days' strength) for each 1 per cent. additional fineness up to about 91 per cent. through a 200-mesh sieve, after which the results are erratic. He found, however, that the additional strength gained by a 1 per cent. additional fineness was about the same as that gained by a 1 per cent. increase of cement.

In later issues we hope to publish fairly full abstracts from these papers.

Tests of Concrete Tanks for Oil Storage.—In a paper with the above title, read before the American Concrete Institute, J. C. Pearson and G. A. Smith describe the results of a series of tests made by the Bureau of Standards for the concrete-ship section of the Emergency Fleet Corporation to determine the effectiveness of concrete as a retainer of oil. Tests were made with various oils in small containers of concrete of the usual 1 : 2 : 4 mix and of the richer 1 : $\frac{2}{3}$: $\frac{4}{3}$ mix of the concrete ships, the latter being tested also under a 25-ft. head. The results are summarised by the authors as follows :—

1. Various mineral oils, covering practically the entire range of fuel oils, have been stored in concrete tanks approximately 13 months, apparently without injuring the concrete in the slightest degree.

2. Concrete test cylinders, 6 in. by 12 in., have been stored in these oils during the same period and have shown no appreciable diminution in compressive strength.

3. A number of vegetable and animal oils have been stored successfully in concrete tanks for a period of 13 months, and only two, cocoanut oil and lard oil, have appreciably attacked the concrete.

4. Quantitative losses of fuel oils have been determined in 1 : $\frac{2}{3}$: $\frac{4}{3}$ concrete tanks under pressures of 12 to 15 in. of the oils, and in a smaller number of tanks, under a pressure head of 25 ft. These measurements indicate that even under the latter conditions heavy and medium-weight fuel oils can be stored in concrete of this character without excessive losses. The storage of kerosenes and gasolines under these conditions will probably prove uneconomical, unless some impervious coating can be found which will be durable under long exposure to the lighter oils.

5. In a single test of six months' duration, spar varnish has apparently been effective in successfully retaining a 43° kerosene of 0·015 viscosity. The loss during this period has been practically negligible.

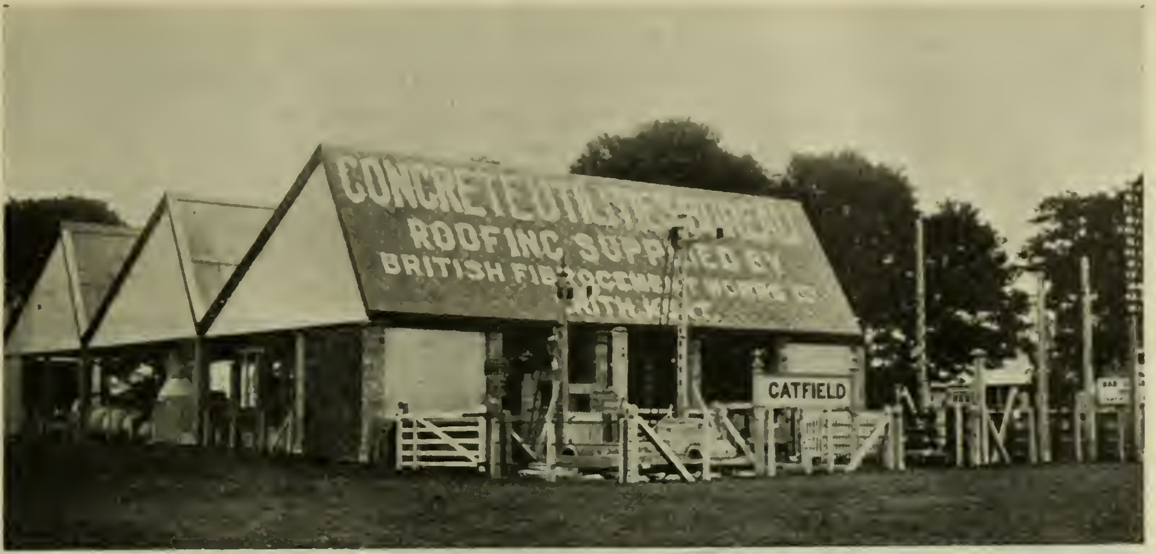


Fig. 1. General View of Concrete Utilities Bureau Stand.

CONCRETE AT THE ROYAL AGRICULTURAL SHOW, CARDIFF.

AFTER its suspension during the later part of the war, the Royal Agricultural Show was, in itself, a notable event, and it was only fitting that in such a typically national function, concrete, the constructional material of the future, should be adequately represented, since, if ever there was a time when the claims of this material should be brought prominently before the public that time is *now*.

In the minds of many people, perhaps the majority, concrete is associated principally with great constructional undertakings such as docks, harbours and breakwaters; or it is regarded as suitable, chiefly, for foundations or other forms of mass work where weight combined with strength is the chief desideratum. Want of information as to the nature of concrete and its great adaptability is, of course, responsible for this attitude. Wider knowledge would teach that concrete is not only invaluable in great works, but is peculiarly applicable to an infinite variety of minor uses on the estate and farm, in the home and garden, in town and country, and for road, mine and railway.

It was in order to illustrate the employment of concrete for such uses as these that the Concrete Utilities Bureau of 6, Lloyds Avenue, London, E.C.3, conceived the idea of a stand at the Royal Show, which should be a purely educational exhibit, and which should demonstrate the great adaptability and utility of the material and the wide range of its possibilities both known and suggested. This idea was duly carried out, and it was admitted by the officials of the Royal Society and by writers in the Agricultural Press that the concrete stand was one of the most educational, practical and instructive that had ever been included in the Show.

Fig. 1 shows the general arrangement of the stand, the greater portion of which was covered in. The roof, which was supported on concrete and steel piers, was partly glazed and partly covered with corrugated cement-asbestos sheets, and slates of the same material. The wall panels were pebble-dashed externally and formed an effective illustration of the variety of colour and texture which may be obtained on concrete surfaces. The cement-asbestos roofing was supplied by the Fibrocement Works, Erith, and the concrete blocks for the piers by Messrs. Aitken and Morcomb, of Cardiff.

This type of structure appealed to many estate owners and f rmers as being eminently suitable for sheds of various descriptions, while others saw in it great possibilities of adaptation to garages and workshops.

THE FARM AND ESTATE.

The value and importance of good fencing is appreciated by every landowner and every farmer; hence concrete fence posts in great variety were included in the exhibits. There was the ordinary tapered post with wire fencing, concrete posts fitted with wooden rail, or rail and pale fencing, posts perforated for tubular iron rail fences, and concrete posts with concrete rails. Testimony to the strength of the last-named type of fencing was afforded by the fact that each rail not infrequently was called upon to support the weight of four or five people.

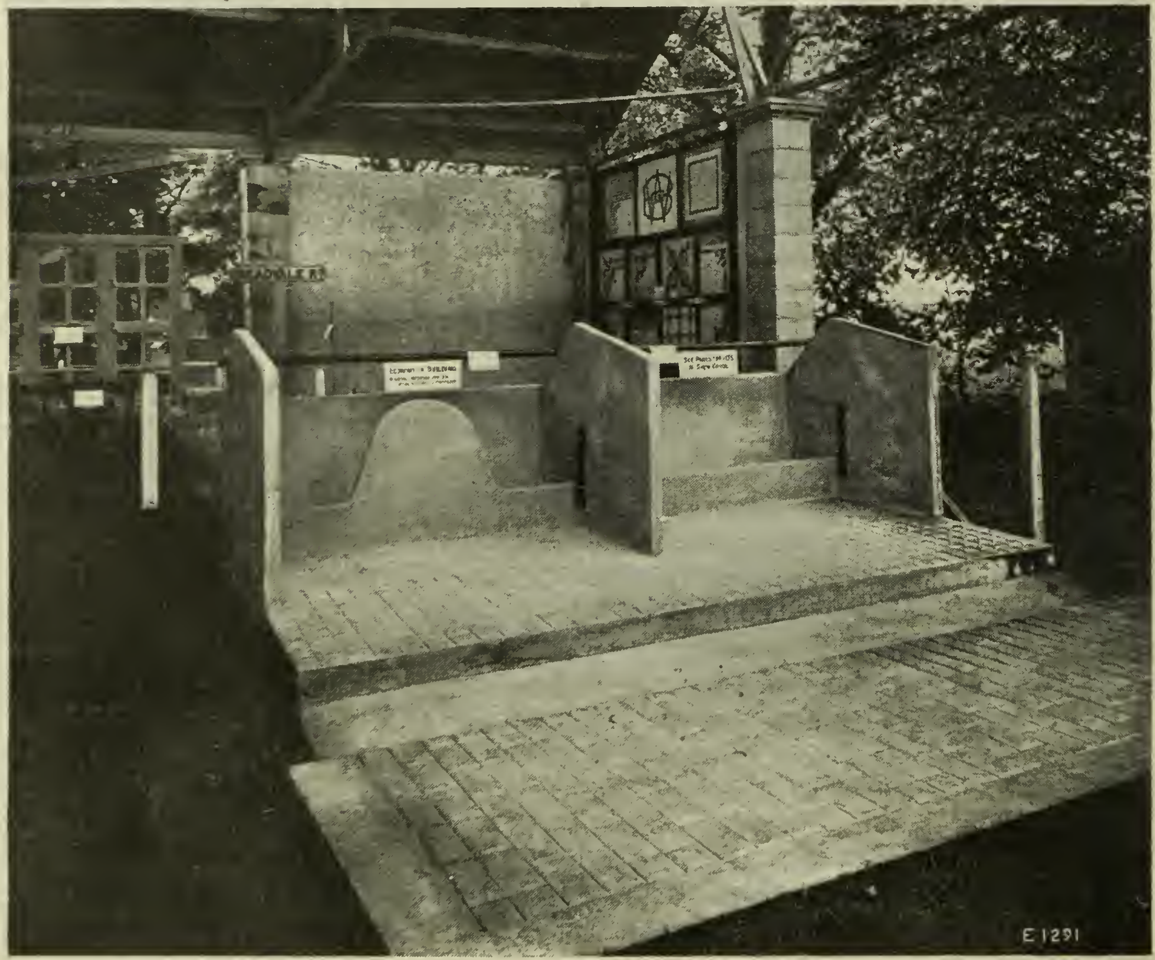


Fig. 2. Concrete Cow-Stalls erected *in situ* by Messrs. B. Ward & Co., of Cardiff. Behind are seen some of the examples of mosaic supplied by the same firm.

An exhibit of great interest to farmers and stockbreeders was a pair of concrete cow-stalls with manger, gutter, and gangway floor complete, supplied by Messrs. B. Ward & Co., floor specialists, of Cardiff. These stalls, shown in *Fig.* 2, were constructed on the specifications recommended by the Board of Agriculture, and their appearance and design were suggestive of cleanliness, sanitation, and health.

In view of the important part that agriculture and dairy farming will undoubtedly take in the national life of the future, and the growing adoption of the practice of ensilage, it was a commendable thought on the part of the Bureau to build a section of concrete silo. This structure was erected by Mr. W. Hopkins, of Leonard Stanley, Glos., a concrete expert who gave frequent demonstrations on the method of construction and on the use of his special form of mould and hoisting apparatus.

Near the silo was a tank partly sunk in the ground and built of concrete blocks moulded on the site. This was designed especially as a liquid manure tank, but it is equally suitable for use as a water tank. In tropical countries such a receptacle would be invaluable, since it could be filled in the rainy season and the water stored for use during the ensuing drought. *Fig.* 3 shows the tank with the silo behind it.

An exhibit which attracted a good deal of attention was a concrete pigsty moulded in sections which were bolted together, the sleeping portion being roofed with concrete tiles. This structure, a view of which is seen in *Fig.* 4, was designed as a tenant's fixture to meet the needs of the smallholder.

Great interest, too, was shown in a garden frame illustrated in *Fig.* 5, constructed entirely of concrete, including both sash bars and sashes. This, like the pigsty, was moulded in sections.

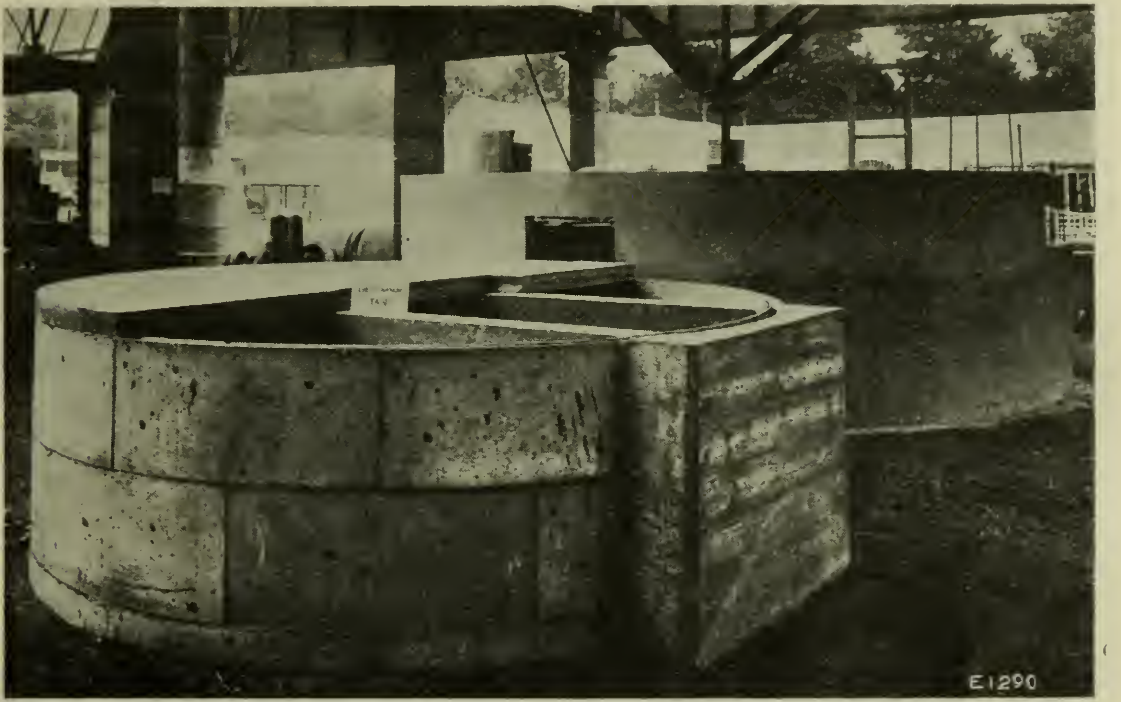


Fig. 3. Liquid Manure Tank built of concrete blocks, behind which is seen the section of a concrete silo.

Other articles intended for use on the estate and farm were gate posts, rectangular and circular tanks and troughs, side by side with which were the moulds in which they were cast; steps contributed by the Patent Victoria Stone Co., Ltd., and the Empire Stone Co., Ltd., both of London, and a variety of the actual moulds in which many of the articles exhibited had been cast.

A very instructive exhibit was a long range of trays containing aggregates collected from the district in which the show was held. This pointed to the widespread nature of the material of which concrete is composed, and emphasised the fact that some suitable aggregate may be found in practically every part of the kingdom.

MUNICIPAL WORKS.

Concrete is now being used to an increasing degree by public authorities, and excellent examples of the application of the material to this form of work were on view. A portion of a reinforced concrete road had been laid down arranged in sections, so as to show each stage of the construction. This was bordered by a section of concrete slab pavement complete with kerb and channel, supplied by the Patent Victoria Stone Co., Ltd. Through an opening in the pavement a tree was growing, and this was surrounded by a latticed tree-kerb, a useful example of the substitution of concrete for iron. These structures are shown in *Fig.* 6.

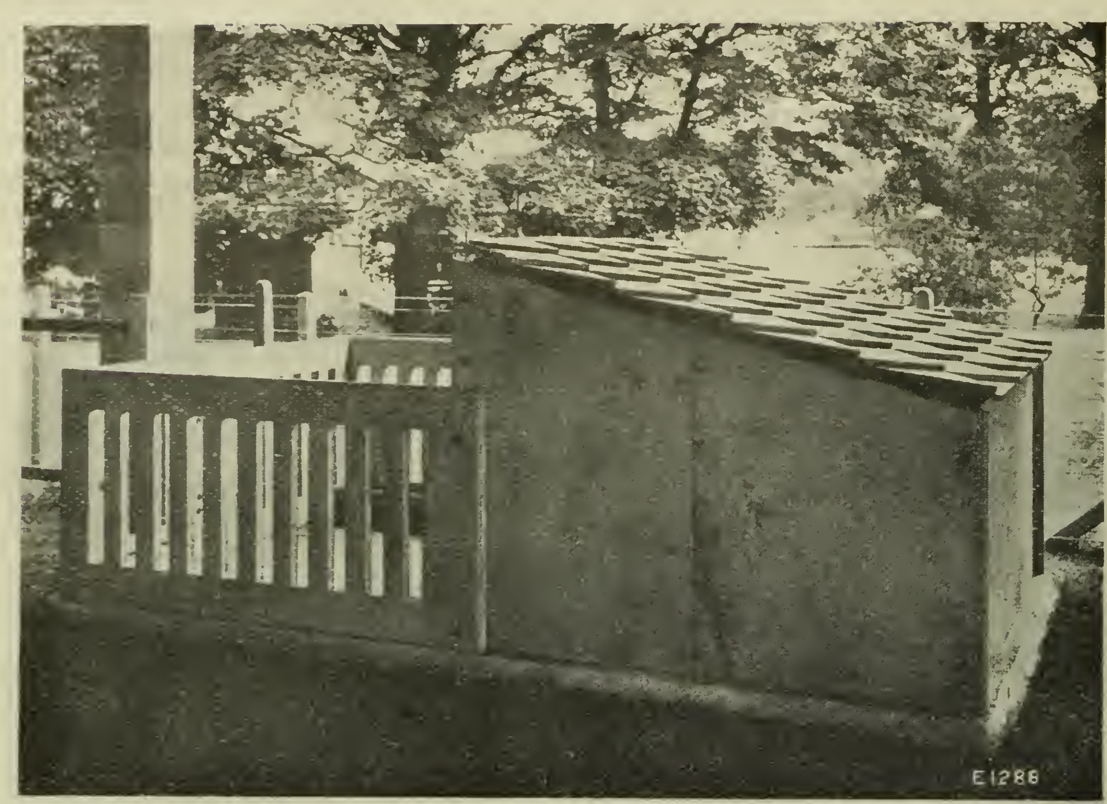


Fig. 4. Concrete Pigsty constructed of pre-cast slabs bolted together and roofed with concrete tiles. Within the pen can be seen portion of a concrete pig-trough.

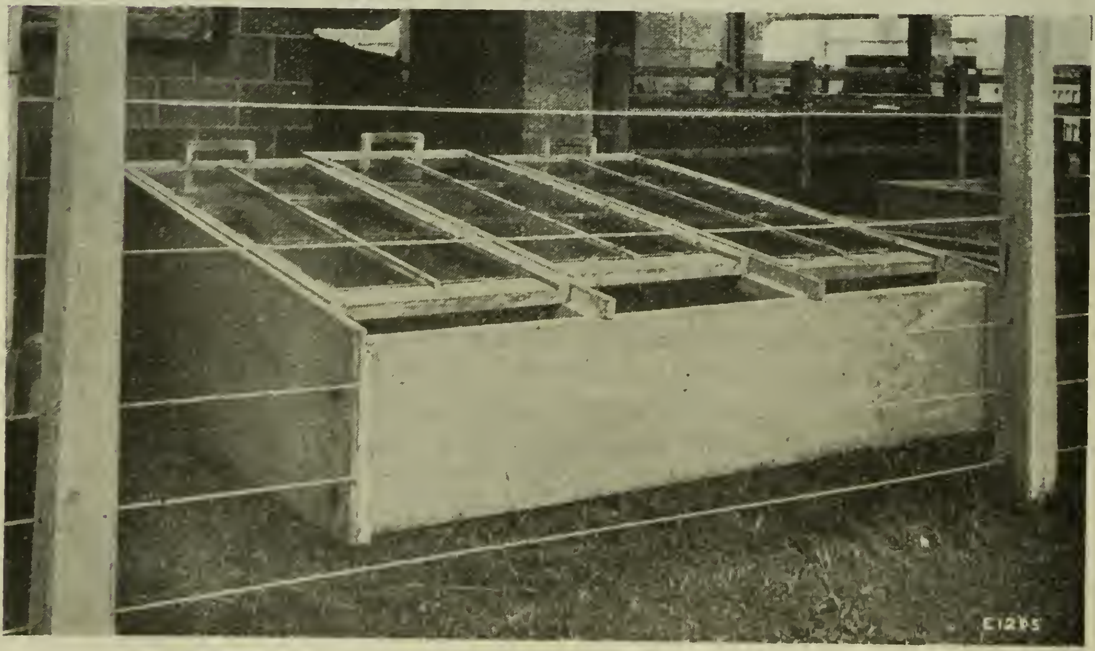


Fig. 5. Concrete Garden Frame with concrete sashes and sash-bars.

Another length of concrete kerbing, and a novelty in the form of a pavement gutter were supplied by the Aylesbury Borough Council who, for some time past, have been carrying out concrete work of this nature.

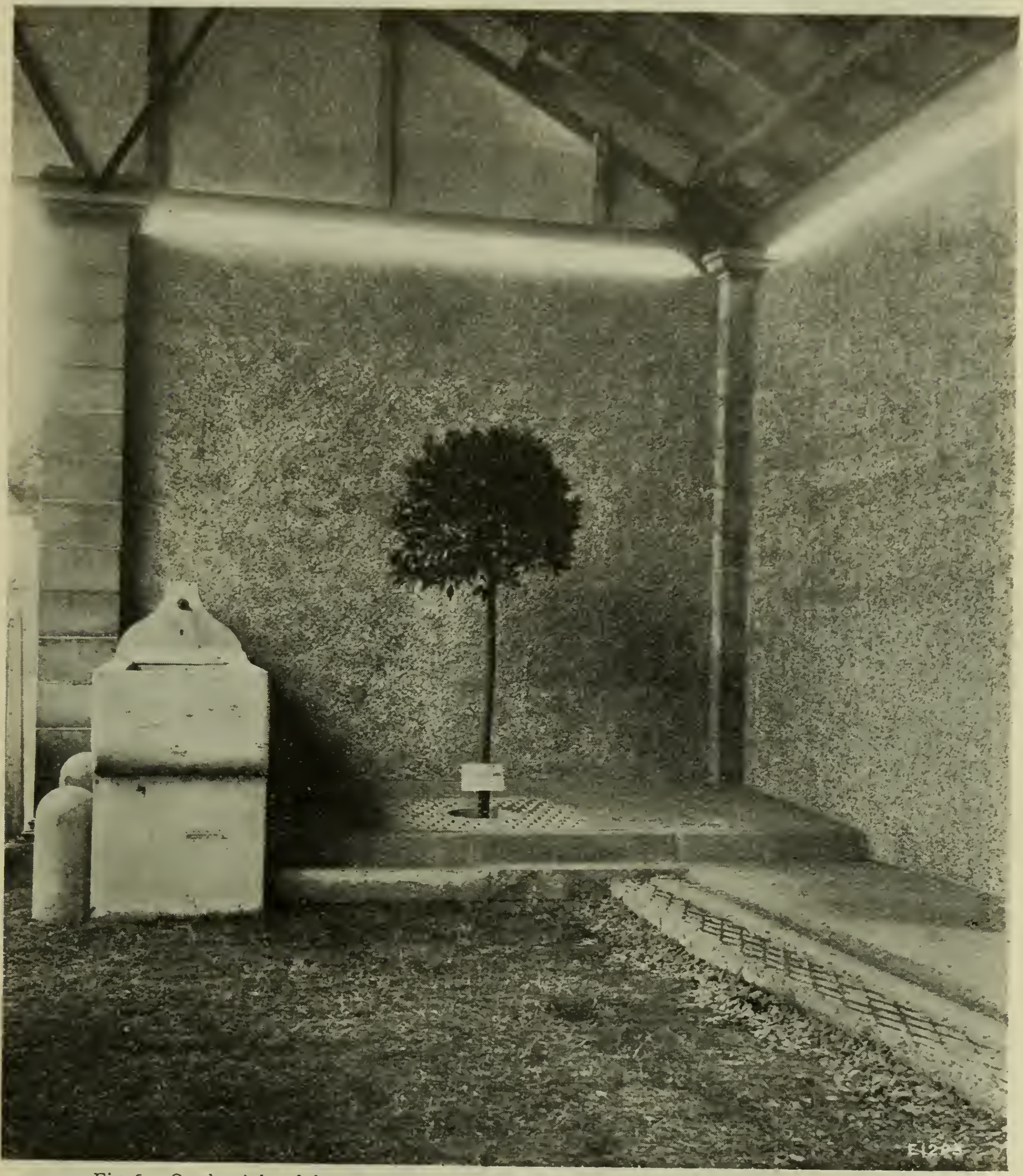


Fig. 6. On the right of this picture is the section of a reinforced concrete road showing the method of construction. Beyond this is a short stretch of concrete pavement and tree-kerb supplied by the Patent Victoria Stone Co., Ltd., and on the left a street drinking fountain by Messrs. Stuart's Granolithic Co. The wall panels are rough-cast.

Messrs. Sharp, Jones & Co., of Parkstone, Dorset, contributed a range of concrete pipes from 1 ft. to 5 ft. in diameter. In addition to these, the same firm supplied a length of sewer piping showing how a curve could be negotiated instead of sending the pipe line to a chamber from which the continuation proceeds at right angles. A view of this is shown in *Fig. 7*.

A handsome and well-finished street drinking fountain, seen on the left of *Fig.* 6, was contributed by Messrs. Stuart's Granolithic Co., Ltd., London, and its clean, neat appearance and the perfect adaptability and economy of concrete for this purpose arouses the wonder that such structures are not more common.

Another novelty in the application of concrete was seen in a couple of rose ladders supplied by the County Borough of Croydon who, by the way, make use of the clinker from their refuse destructors as aggregate for some of their concrete products. The rose ladders are used in the public gardens of Croydon, and, as their name suggests, act as supports for the training of roses. They are so shaped that they may be placed side by side to form a screen, or they may be adapted for use as a pergola. The two examples may be seen in the first and third openings on the left-hand side of *Fig.* 1.

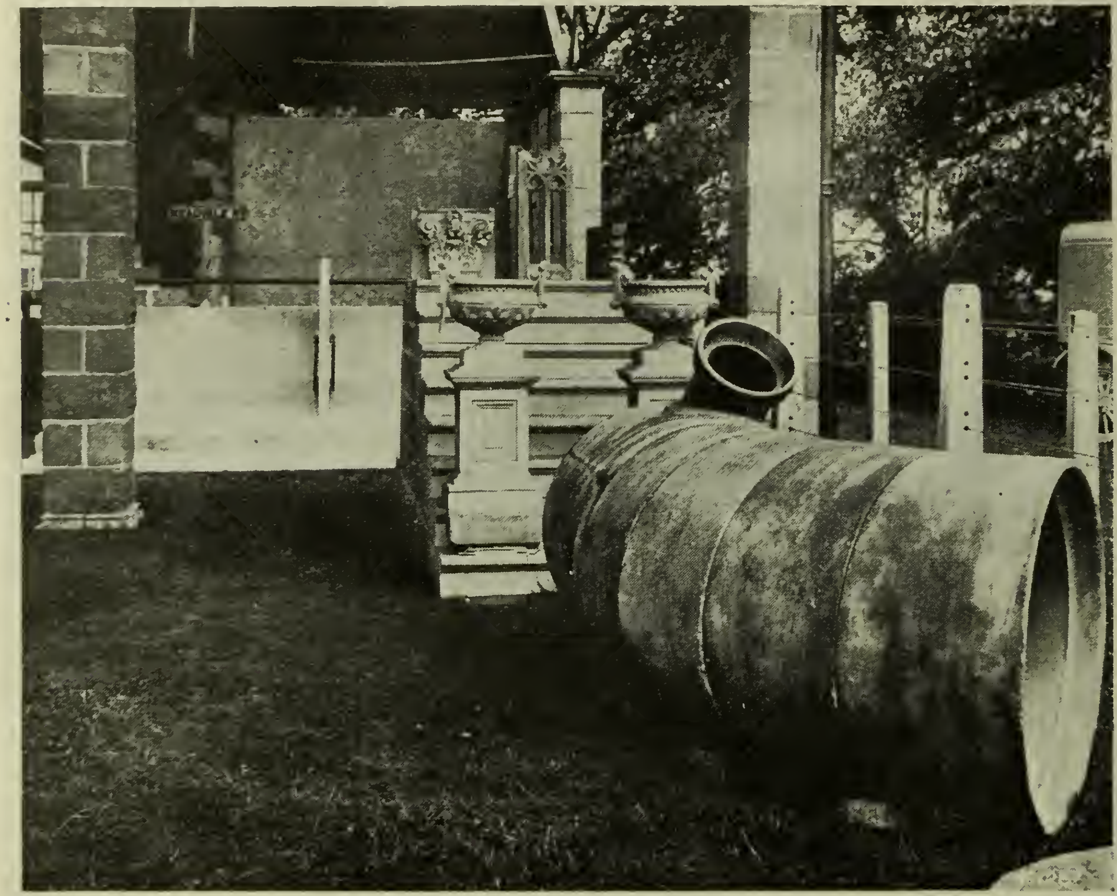


Fig. 7. In this photograph are seen Concrete Sewer Pipes on the curve, supplied by Messrs. Sharp, Jones & Co., and Concrete Steps, Vases and Pedestals, Carved Panels and Capital supplied by the Victoria Stone Company, Limited.

CONCRETE SURFACE FINISH AND ORNAMENTS.

The artistic side of concrete is well represented by delightful examples of mosaic supplied by Messrs. B. Ward & Co., concrete wall surfaces of various types and colours, well-designed and well-finished vases, pedestals, carved panels, and capital by the Patent Victoria Stone Co., Ltd., and numerous other examples of ornamental work.

BUILDING CONSTRUCTION.

Since the housing question, being a matter of national moment, is now very much to the fore, it is not surprising that concrete, as applied to building construction, occupied a prominent place in this collection. In the centre of the stand the Bureau

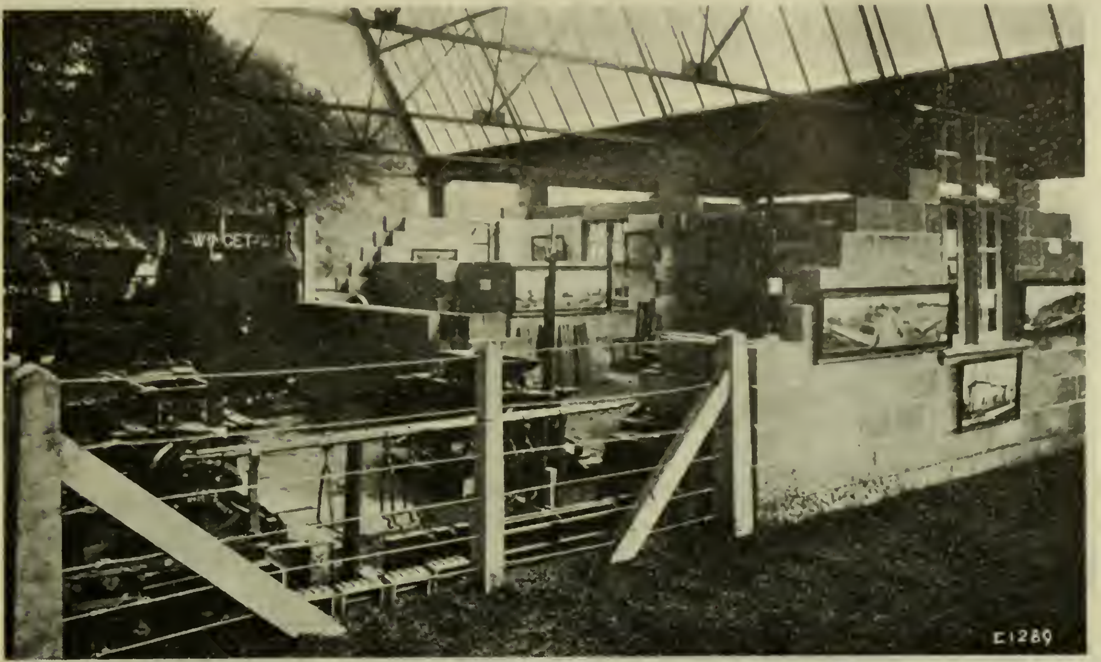


Fig. 8. General view of a partly-erected Cottage with cavity walls built of concrete blocks. At the right of the picture is seen a Concrete Window-Frame by Mr. W. Marriott, and within the enclosure some of the Winget machines in which the blocks were moulded.

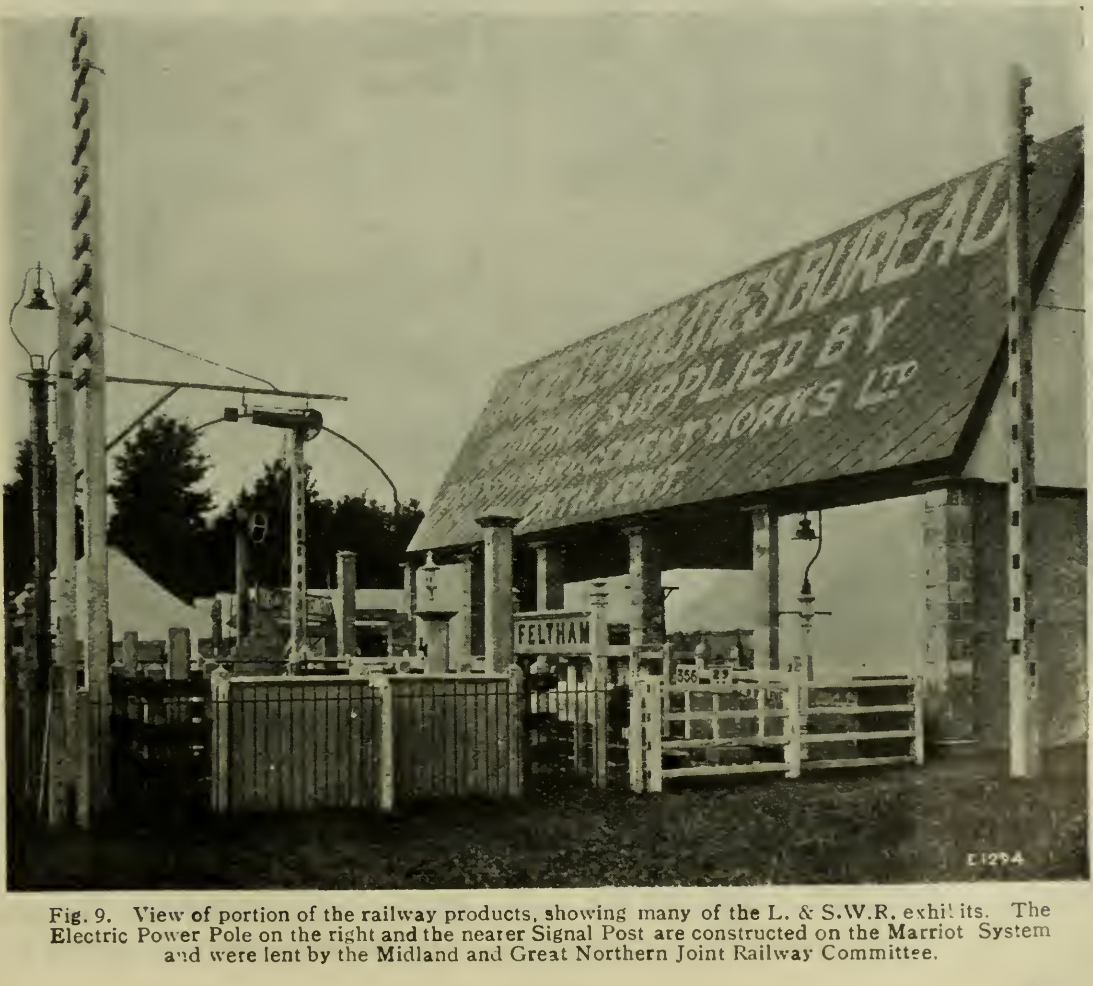


Fig. 9. View of portion of the railway products, showing many of the L. & S.W.R. exhibits. The Electric Power Pole on the right and the nearer Signal Post are constructed on the Marriot System and were lent by the Midland and Great Northern Joint Railway Committee.

had erected a partly built cottage having cavity walls constructed of concrete blocks. The building had been left incomplete in order that the method of construction might be examined in detail. The space within the walls was occupied by Messrs. Winget, Ltd., London, who exhibited several of their well-known machines for moulding concrete blocks, slabs, and drain-tiles, and their chain-mixer which was driven by a small petrol engine. An entirely new hand-pressure block-making machine, only just placed on the market by Messrs. Winget, attracted considerable attention on the part of builders, estate owners, and representatives of public authorities. This is a well-thought-out machine, lower in price than their original model, and designed for moulding solid blocks for use in cavity walls. At the demonstrations which were

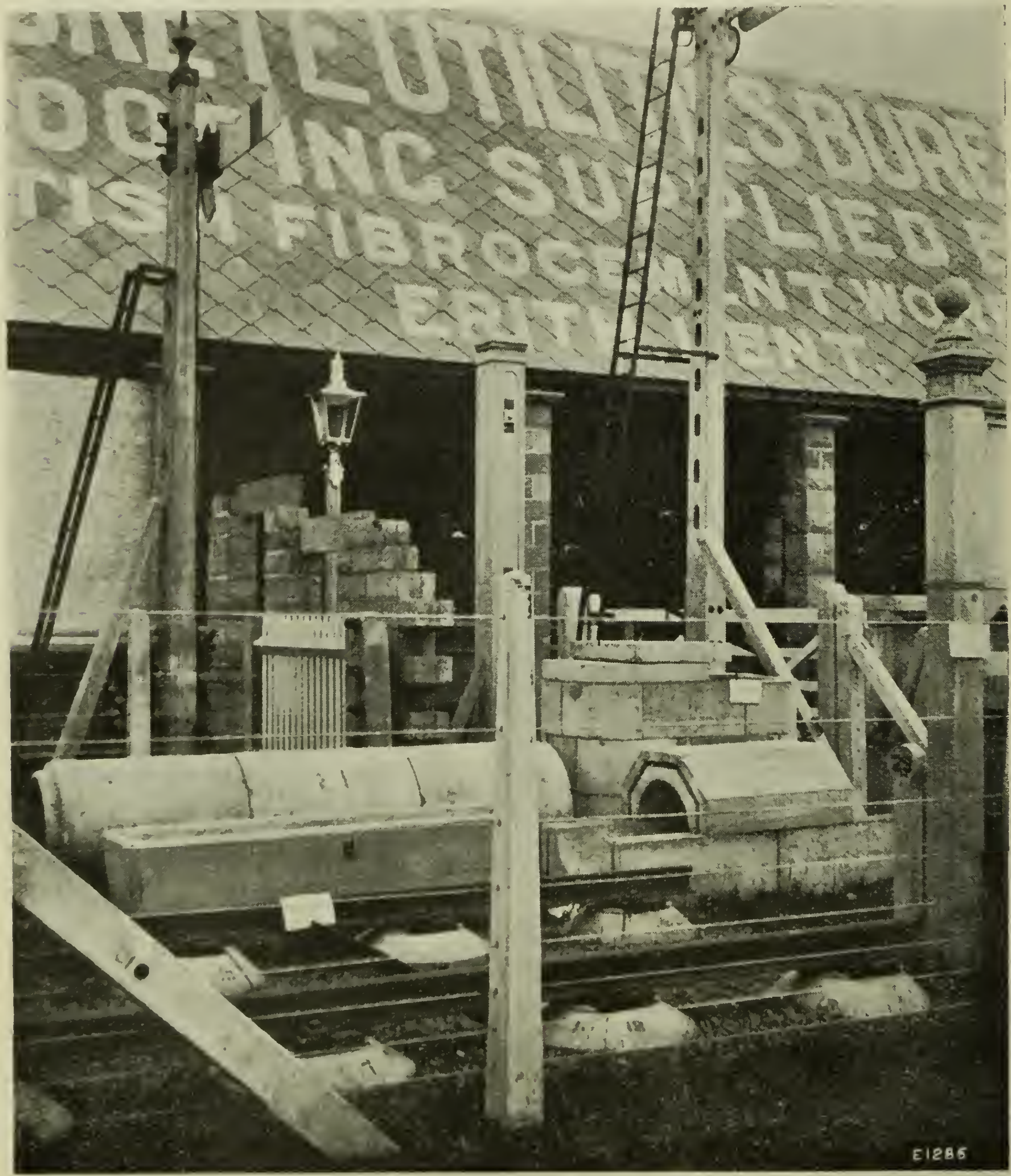


Fig. 10. View of another portion of the railway products, showing the Great Western Exhibits in the nearer enclosure and those of the Cheshire Lines Committee beyond. The two Level Crossing Gate Posts and the Signal Post between were contributed by the Midland and Great Northern Joint Railway Committee.

frequently carried out, blocks were moulded by two men at the rate of about two per minute, exclusive of the time occupied in mixing. A general view of Messrs. Winget's exhibit, together with portions of the cottage wall, and a concrete window frame, by Mr. W. Marriott, is shown in *Fig.* 8. Other window frames were supplied by the Empire Stone Co., Ltd., and Messrs. Stuart's Granolithic Co., Ltd.

RAILWAY WORK.

In no direction, perhaps, has the development of concrete been more remarkable than on the railway, and the enormous number of uses to which this material has been applied, and of which the exhibits at the Concrete Utilities Bureau stand are only types, is in itself a guarantee of its efficacy and its economy. Among the specimens were to be seen lengths of railway track laid with concrete sleepers of various designs, as seen in *Figs.* 10 and 11 ; signal posts and telegraph posts with all their fittings complete ; electric power poles in actual use ; fence posts of many kinds, panel fencing, lamp-posts for platform and yard, electric light standards, boundary posts, gradient posts, mileage posts, level crossing gate-posts, field gate-posts, stumps for protecting gate-posts, load gauge post, gang posts, signal wire pulley stakes, a cattle pen, sections of railway station platform, unclimbable platform fencing, a wicket, culverts of different types, troughs, an inspection chamber, chequered paving slabs for stables, etc., a cable box, roller blocks, crank horse legs, steps, window frames, door frames, kerbing and channelling.

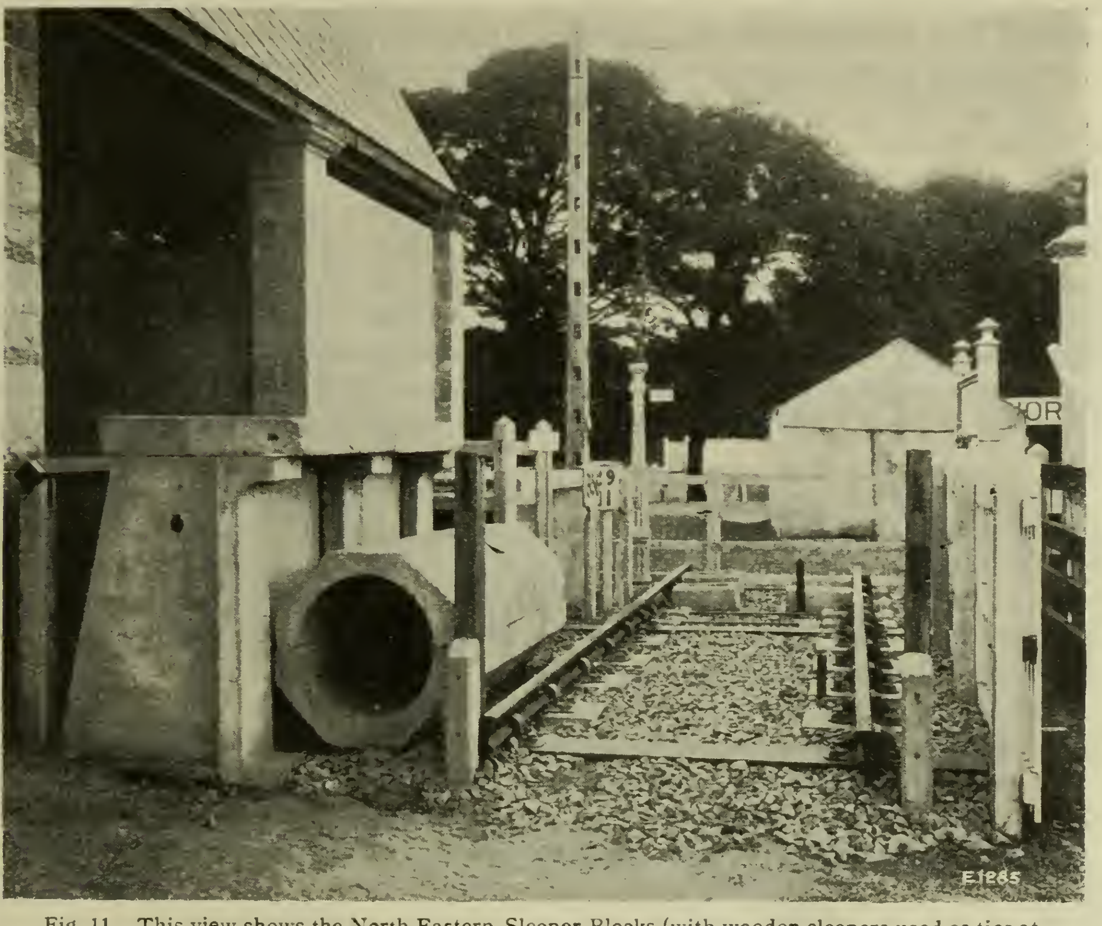


Fig. 11. This view shows the North Eastern Sleeper Blocks (with wooden sleepers used as ties at intervals) and beyond these the Meyrick Sleepers, Bridge Number Plate, Distance Post and Gradient Post, lent by the L. & S.W Rly., and on the left a hexagonal culvert and section of Concrete Railway Platform contributed by the North Eastern Railway.

Excellent examples of concrete lettering were seen in station name-plates, bridge number plates, gradient posts, mileage posts, and gang posts. In these, black concrete letters stand out in relief on a white concrete background, and the whole is not only neat and effective, but, since concrete requires neither paint nor preservative, is permanent and economical.

So clean and well finished was the appearance of the station name-plates, lent, respectively, by the London & South Western Railway Company and the Midland and Great Northern Joint Railway Committee, that visitors frequently mistook the material for freshly painted woodwork. The former ("Feltham") is seen in *Fig.* 9, and the latter ("Catfield") stands out well in *Fig.* 1.

Space forbids our describing these railway exhibits in detail, but a scrutiny of the list given above, many of the articles in which will be recognised in *Figs.* 9, 10, and 11, will make it abundantly clear that a very considerable economy in timber, bricks, iron and steel may be effected by the use of concrete for articles and structures such as those mentioned—a conclusion fully borne out by the experience of railway engineers who have adopted the method. It was admitted on all hands that this section formed a very striking exhibit.

The specimens enumerated above were lent by the following railway companies: The Great Western, the London & South Western, the Great Northern, the North Eastern, the Midland and Great Northern Joint Committee, and the Cheshire Lines Committee. It may here be mentioned that the concrete sleepers lent by the London and South Western Railway were made to the design of Mr. W. H. Meyrick, those, together with the other concrete products in use on the Midland and Great Northern Joint Railway, are constructed on the patent system of Mr. W. H. Marriott, while the circular pot sleepers contributed by the Great Western Railway and seen in *Fig.* 10, were designed by Messrs. Rendel, Palmer, and Tritton. Other types of concrete sleepers were supplied by Messrs. Trollope and Colls, and Trent Concrete, Ltd.

During the show demonstrations of actual concrete moulding were carried out at frequent intervals in order to show how easily this material is manipulated, and how simple a thing is the making of a fence-post, a gate-post, or a trough, at the same time giving an exhibition of the correct method of carrying out the operations. These demonstrations were watched with the keenest interest by large numbers and added greatly to the attractiveness and usefulness of the exhibition.

This stand was one of those selected for the honour of a visit by H.R.H. the Prince of Wales, and the thoroughness with which the heir apparent enters into social and industrial questions was again displayed in the keen interest taken by him in the exhibits, and in his comments and enquiries on different points of detail.

Altogether some fifty or sixty thousand persons passed through this stand during the show week, and included many landowners, estate agents, members of public bodies, as well as builders and contractors, to whom the advent of concrete in this form undoubtedly affords opportunities of extending their business, and we advise those who were unable to see the display at Cardiff to take an early opportunity of visiting the permanent exhibition which the Concrete Utilities Bureau has arranged at 143 Grosvenor Road, London (near Vauxhall Bridge), where duplicates of many of the articles mentioned in the foregoing notes are on view.

In our next issue we propose giving a brief description of the stand of Messrs. Turner Bros., Rochdale, who had a most interesting exhibit showing the use of asbestos cement for building purposes.

THE HOUSING QUESTION.

The use of machinery for building concrete houses and the case of bricks v. concrete have been discussed very ably in two articles which have recently appeared in the "Builder" from the pen of an Anglo-Australian Resident Engineer. The points raised by the writer are of importance and call for the special attention of those who are about to undertake housing schemes in different parts of the country. By the courtesy of the "Builder" we reproduce the first of these two articles; it covers practically all the points raised in the second article.—ED.

MACHINERY FOR BUILDING CONCRETE HOUSES.

CONCRETE houses, to the average mind, are associated with the old-fashioned grey block buildings, with stereotyped faces in imitation of stone.

The modern method of reinforced concrete construction lends itself to any design and numerous artistic finishes, such as white Portland cement, a production of recent years, rough cast; the familiar garden city house finish, half timber reproductions in cement, leaving a perfect impression of the grain of the timber on the face of the cement bands, which may be stained, and the panels finished in Kentish Rag rough cast; another artistic finish is rough cast to the height of the ground floor walls, and the upper floor walls finished in a reproduction of vertical tiling, plain or ornamental, perfect in colour and finish, of old or new tiling, without any of the defects of the original. Another pleasing effect is to cast the wall slabs with sunken joints in imitation of stone, the upper storey being finished in rough cast, for imitation vertical tiling.

A pre-cast reinforced concrete wall, 2 and 1½ in. in thickness, composed of two parts of clean, sharp sand, four parts of gravel or ballast, graded from ½ to ¼ in., and one part of Portland cement, can be made perfectly non-porous. For successful waterproofing the compound should be mixed with the dry cement by machinery, and not by the usual haphazard hand-mixing process.

In colouring the face of concrete when casting, the colour mixture should be added to the dry cement, and thoroughly mixed by machinery. For block facing, manganese dioxide should be used; for green and red in vertical and roofing tile reproductions, chromium oxide and Chattanooga iron ore; for slate colour, manganese dioxide; for terra-cotta, red iron ore. With these colouring materials quite a large number of artistic finishes may be given to concrete houses. Manufacturers have placed upon the market a number of stains especially made for concrete. They can be easily and quickly applied, and their covering power is at least twice that of oil paint, which is unsuitable for new cement or concrete work. The majority of cement and concrete colouring materials are the products of American manufacturers, and are very little known to architects in this country.

The great demand for and the scarcity of bricks has brought concrete blocks more into use for building purposes; these are made with semi-wet concrete and should be well rammed, preferably by machine tampers, and the concrete mixed by machinery, for which purpose batch mixers of 2 ft. capacity and upwards have been produced by American manufacturers. Concrete block machines are produced very cheaply in America, and may be obtained for from about £10, with a complete set of face plates for the manufacture of blocks with rock face, rock-face tooled margin, bush-hammered tooled margin, tooled, panel, plain and various others. There are many makers of block machines, some make face-up machines, others face-down. There has of late years been placed upon the market a machine with a capacity of 1,000 blocks per day, of excellent quality. It weighs about 10 cwt., and 100 tons pressure can be applied by a system of toggle leverage; the concrete is pressed into dense compact blocks from two to three times faster than by any other process. Three movements only are required to complete a block. One movement applies the pressure; one delivers the block; and one returns the box ready for the material; there is no loss by cracked blocks, and a wall with a continuous air-space may be constructed with them. With all its advantages this machine is not yet upon the market in this country, and we are contented with the old and slow type of block machine.

We have much to learn in this country about handling and building in concrete. Numerous wheelbarrows and a large stationary mixer is an antiquated and costly method for concrete work; the long hours and low wages ruling in pre-war days caused the employing contractor to give very little consideration to the employment of additional men and the neglect of machinery and labour-saving devices for building construction. Mixing concrete by hand with the old-fashioned concrete gang should never be permitted, as it results in imperfectly mixed concrete and heavy cost. I have known a gang of twelve Chinese women concreters mix and place 21 cu. yds. of concrete in nine hours; on my return to England in 1916 I watched a similar number of men concreting on a job at Whitehall, and their work was not equal to one-half of that amount, and the concrete was not half mixed. One navvy wheeled about half a barrow of concrete to another navvy who was waiting for him with an empty barrow, the second man continued the journey to the place of deposit, after some conversation, and his mate returned with the empty barrow for which the concrete gang were waiting. Good and efficient management, and the full use of up-to-date machinery and labour-saving appliances are the requirements for building construction here; with expensive labour and small output it is an absolute necessity. With the right plant it is possible to erect a block of four pre-cast reinforced cottages in ten days, and a double chimney to a two-storey house in four hours, without scaffolding; houses and chimneys can be erected by an ordinary 5-ton crane, without scaffolding, in less time than it takes to erect and remove an ordinary bricklayers' scaffold. These houses comprise posts, beams, and slabs of reinforced concrete pre-cast on the building site in a horizontal position. Wall slabs are cast in adjustable frames, and the roofs are timberless and improve with age. An equivalent to upwards of 800 bricks can be laid in one operation, and 180 tiles tiles in roofing. If the costly method of brick building were perfect it would be defensible: like the tiling on the roofs, it is constantly under repointing and repair, tiles become broken and blow off, ceilings are continually damaged through faulty roofs. We call ourselves architects and builders, and neglect to remedy our defective building construction methods.

Were bricks obtainable at 20s. per 1,000, delivered on the site, and an average of 1,000 bricks laid in eight hours, it would cost more to build in brick than concrete pre-cast and machine erected. It is impossible to tell the cost of a brick house to-day until the job is finished. We read about British bricklayers laying 700 bricks per day, and American bricklayers laying double that number. I have measured up a number of jobs during the past two years, and the number of bricks laid per day for bricklayer and labourer has been 320; if they were asked to do better, their answer was invariable, "If you are not satisfied, guv'nor, give me my money; there is plenty of work about besides yours." On making inquiries, I find that the cost works out as follows::—

	s.	d.
BRICKLAYER.		
1s. 4d. per hour for 9 hours	12	0
1 hour overtime	1	8
Bonus, 12½ per cent.	1	9
Country money per day	1	6
LABOURER.		
1s. 1d. per hour for 9 hours	9	9
1 hour overtime	1	4
Bonus	1	5
Country money per day	1	6
Total per 320 bricks laid ..	30	11

The above equals £20 per rod for labour only.

With modern methods of reinforced concrete construction there is no necessity for an idle moment for any man employed on the works; if a man is standing idle he is loafing. With the old-fashioned bricklaying and hand labour, it is the work of the labourer to keep the bricklayer supplied with bricks and mortar—the slower the bricklayer, the less work for his labourer; likewise the tiler and other trades.

Unless a concrete job is properly organised and efficiently managed, the work is not carried out quickly. A large number of men with plenty of wheelbarrows and a large concrete-mixer, and all as busy as bees, will not produce the best results in speed and economy. Two ¼-yd. mixers, one placed at each end of the job, will save labour and time, and result in more work in a day than a 1-yd. mixer placed in any other position. It is now possible to obtain run-about mixers with a petrol engine on the same carriage, the whole weighing only 10 cwt.; these are side delivery machines, and can be operated by three men to fill, mix and place the concrete. It costs no more to have the material delivered on the job where it is to be used than it does to dump it in one place near the old-fashioned stationary mixer, the concrete, after mixing, being wheeled to the place of deposit, adding cost to every barrow load.

The cost of centring and casting *in situ* has been the drawback of reinforced concrete in the past. With the new method of standardising members and pre-casting them on the site, reinforced concrete has become by far the best and cheapest method of building construction.

We call ourselves architects, engineers and builders, and we are inclined to ridicule the authorities who sent sand to Egypt to fill sand-bags. There are many millions of tons of shingle on the sea coast of this country; Nature has heaped millions of tons on the Kent coast graded from ¼ in. to ¾ in.—excellent material for fine concrete—not round pebbles, but good, irregular stuff which requires neither excavating, crushing nor screening. Are we to leave it there and dig into the bowels of the earth for clay to make inferior bricks and transport them to the sea coast to construct jerry-built houses that are continually under repair, at double the cost of pre-cast reinforced concrete houses that improve with age and require no repairs to roof or building?

Brighton proposes to build houses at a cost of £900 each, with an additional apportionment of £100 for roads and main sewers; these houses are to be let at 12s. 6d. per week, leaving a deficit of nearly 20s. to be made up by Government subsidy and the 1d. rate. Luton proposes to build concrete houses at £350 each; the latter place must excavate for the ballast, the former can have it for carting. This is but one instance of the reckless expenditure of national wealth on antiquated methods of building construction.

MEMORANDA *re* HOUSING.

Luton.—The Luton Rural District Council has accepted a tender for the erection of 24 concrete houses with concrete staircases and composite floors at £350 each, as against £540 each if erected with bricks.

Hertford.—Two experimental model homes are being constructed at Hertford with concrete slabs of a special design.

Beckenham.—The Beckenham Council have granted permission for the erection of a bungalow dwelling with concrete bricks built in hollow walls, subject to the necessary plans being submitted and approved.

Worcester.—Concrete houses are to be erected in the Pebworth Rural District of Worcestershire by a co-operative society, which estimates that it can build cottages in concrete (each with two living rooms and three bedrooms) for £350 each.

Canterbury.—The special committee of the Town Council appointed to enquire into the possibility and advantage of utilising the clinker made at the city's destruction works in the manufacture of concrete building blocks for use in the Government's housing scheme, having reported favourably, it was decided to vote a sum of £1,000 (up to Christmas next) to be expended in the manufacture of hand-made concrete blocks.

Ypres.—In connection with the re-building of Ypres, we learn from the daily Press that a sort of garden city is being built up behind the devastated cathedral. Streets of four-roomed cottages are being constructed, and gardens laid out.

In various parts of the country 15,000 of these dwellings are to be erected. The walls are made of concrete blocks manufactured at Richborough. This is to be known as New Ypres.

Willesden.—At the housing committee of the Willesden Urban District Council the chairman read a letter from Messrs. Trollope and Colls, Ltd., stating they were desirous of erecting exhibition cottages in the London area with walling of their system of reinforced concrete, and submitted the following proposals:—

(*a*) That the council lease to them at a nominal rent suitable plots of land on the Brentfield Estate.

(*b*) That the council should grant them permission to erect one or two pairs of cottages at their own cost on the selected sites for exhibition purposes, constructed of reinforced concrete walling on their improved method. The planning of the cottages to be either one of the plans suggested in the " Tudor Walter's " Report, or to a suitable plan to be prepared in collaboration with the architect and engineer.

(*c*) The council to have the right to nominate their own tenants to occupy the cottages, the rental of which will be based on economic lines, subject to the cottages being open for inspection during certain hours of the day.

(*d*) The council to have the option of purchasing the cottages at their cost price should they so desire ; and

(*e*) Messrs. Trollope & Colls to clear away if the buildings are unsuccessful.

The committee concluded that the proposal was worth consideration, and recommends that a plot of ground be allocated on the Brentfield Estate for the erection of two pairs of cottages, subject to their design and the material to be used first being approved by the committee.

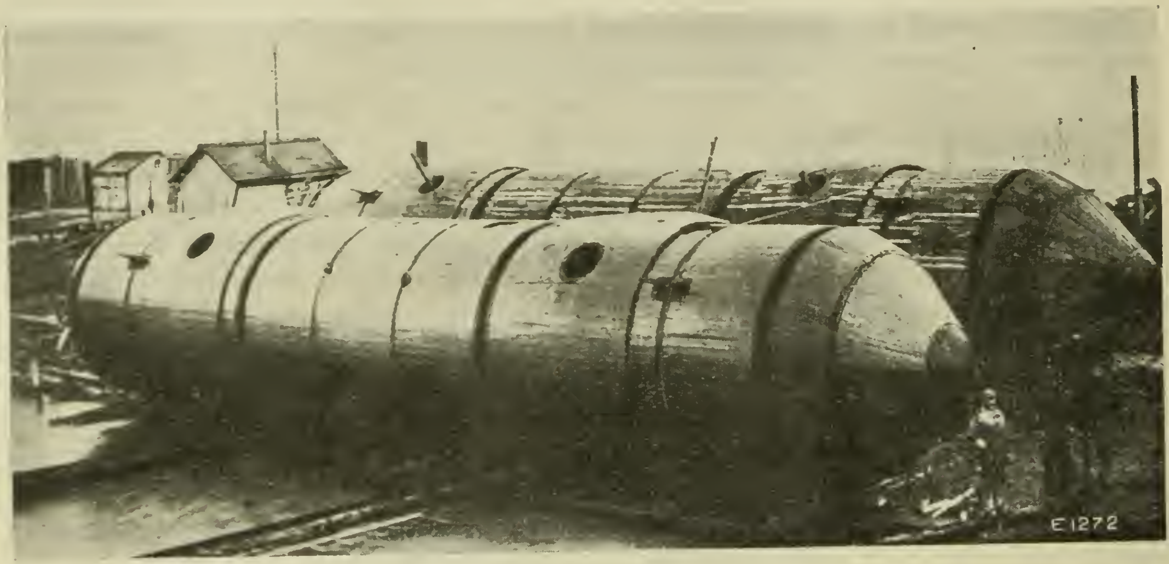
Some Remarks on Laying House Drains on Concrete Beds.—In an article in the *Carpenter and Builder*, Mr. G. Metson states the following :—Where a concrete foundation is provided to receive the drainpipes, such concrete must be properly deposited in the trench. It must not be merely wheeled to the edge of the excavation and tipped from the wheelbarrow to the bottom, but must be lowered in buckets, skips, etc. There are at least two objections to tipping the concrete into the trench : firstly, that parts of it will, unless extreme care is used, come in contact with the earth sides of the trenches, and so be spoilt and wasted ; and secondly, that the concrete loses its proper consistency in its passage through the air, the heavier particles separating from the lighter ones and the mortar, and reaching the bottom first.

When laying drainpipes on a concrete bed, some provision has to be made in the bed to receive the sockets to allow of the barrel of the pipe being on an even bed. One method frequently adopted is to insert small pieces of timber 1½ in. thick in the concrete in the positions to be occupied by the drainpipe sockets, removing them before the concrete is actually set.

Another method is to use a brick, laid flat, for the same purpose, which has this advantage over the wooden slip, that its extra thickness permits the hand of the jointer to have working room completely round the joint.

Yet another method is to place the pipes on bricks resting on the concrete, the bricks being placed near the sockets of the pipes. When the exact lie of the pipe has been determined, small brick wedges are bedded in cement on either side of it to keep it in position. As the pipe is now off the concrete bed, additional concrete is required to bed the pipe up to a solid bearing.

On one job known to the writer, the specification provided for the pipes to be bedded in 1 to 4 cement mortar, and to be rubbed down until the socket of the pipe was in contact with the concrete bed. This made an excellent job.



SALVAGE PONTOONS.

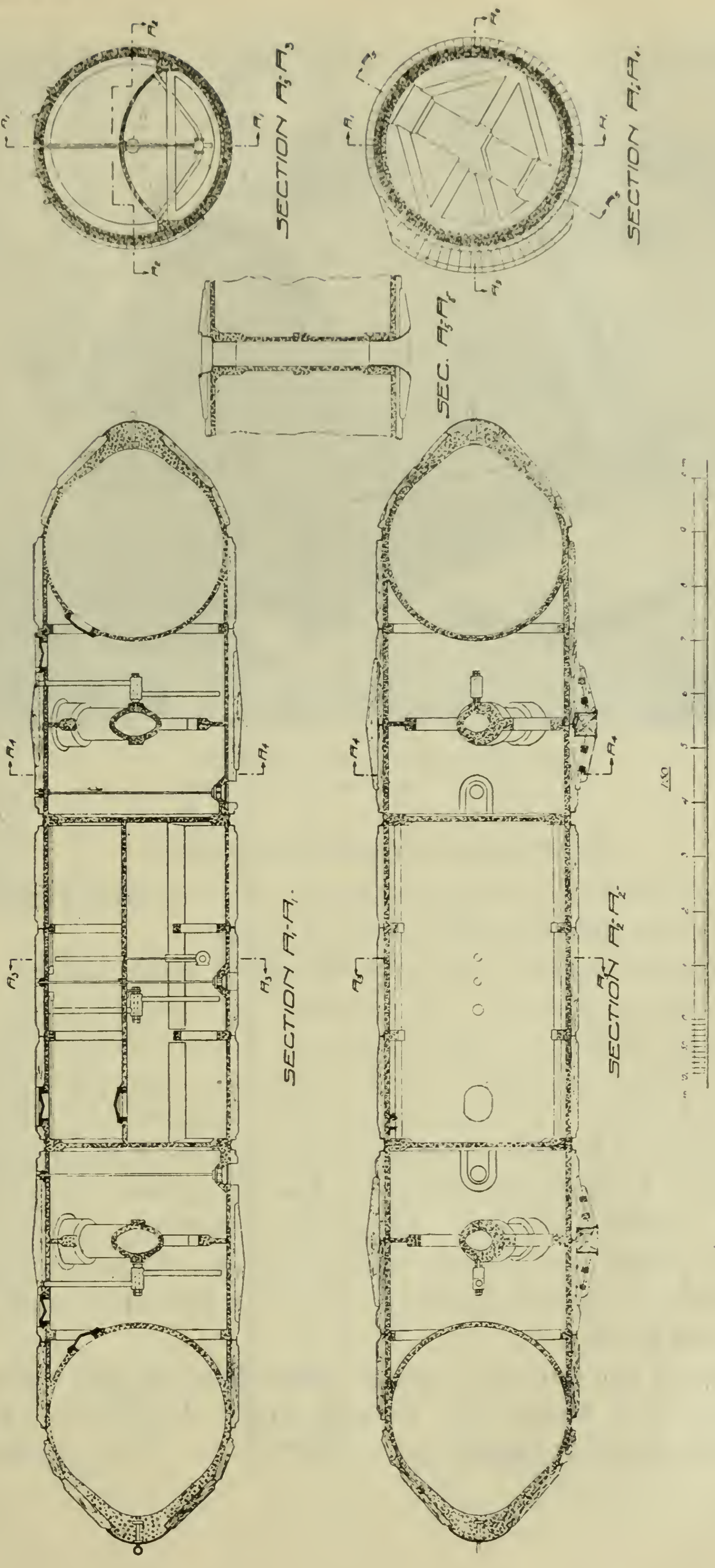
The following short particulars and illustrations are interesting examples of the use concrete for salvage work and for large hangars.—ED.

REINFORCED CONCRETE SALVAGE PONTOONS AND HANGARS.

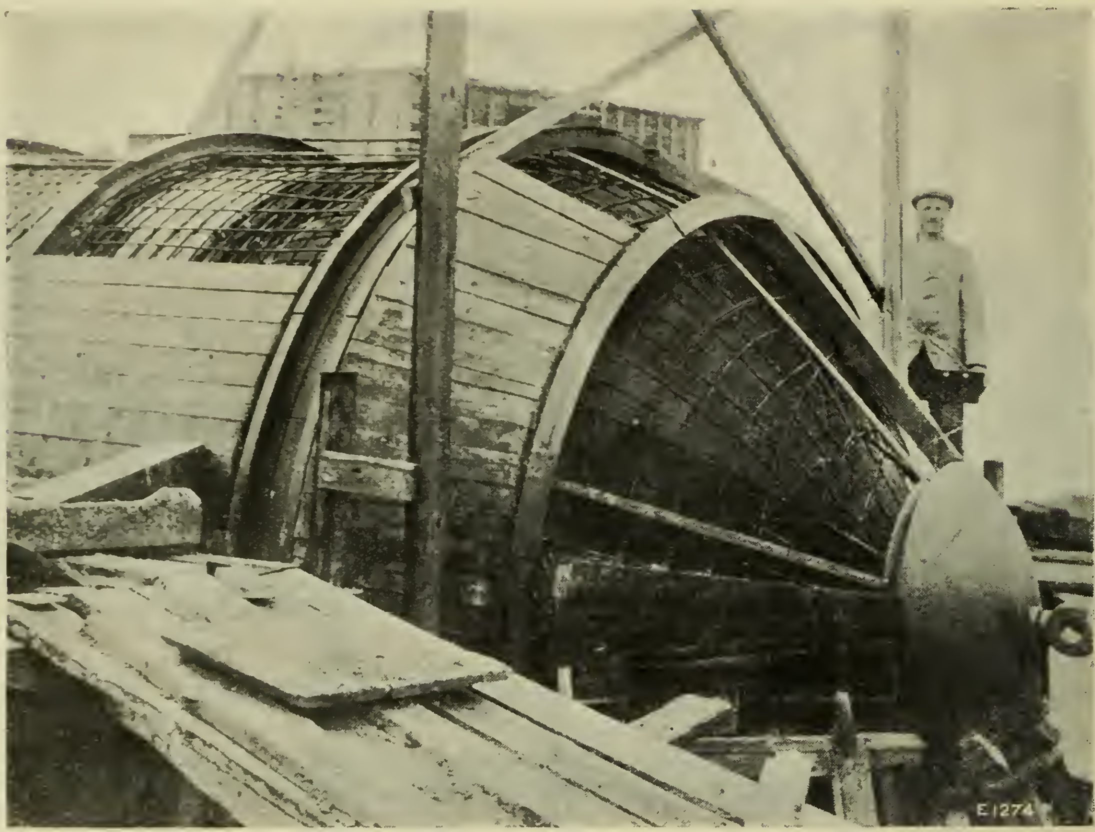
SALVAGE PONTOONS.

A NEW application of reinforced concrete is shewn in the following illustrations of Salvage Pontoons built for Messrs. Switzer's Salvage Company, Copenhagen. The pontoons, which are intended for the lifting of wrecks, etc., are 70 feet long and 14 feet in diameter. The cylindrical shape combines strength with lightness (the walls are only three inches thick) at the same time as being largely adaptable to the different conditions under which the pontoons are likely to be used. Two diametrical tubes for the chains, which are to connect the pontoons with the wreck, cross the hull.

The pontoons are covered with a wooden mantle to protect them in case of collision, and have a lifting capacity of 100 tons each. In spite of their comparatively thin walls, the pontoons can stand a water pressure of 66 feet, which is the depth for which they have been built.



Constructional Details.
Reinforced Concrete Salvage Pontoons.



Showing Pontoon in Course of Construction.
REINFORCED CONCRETE SALVAGE PONTOONS.

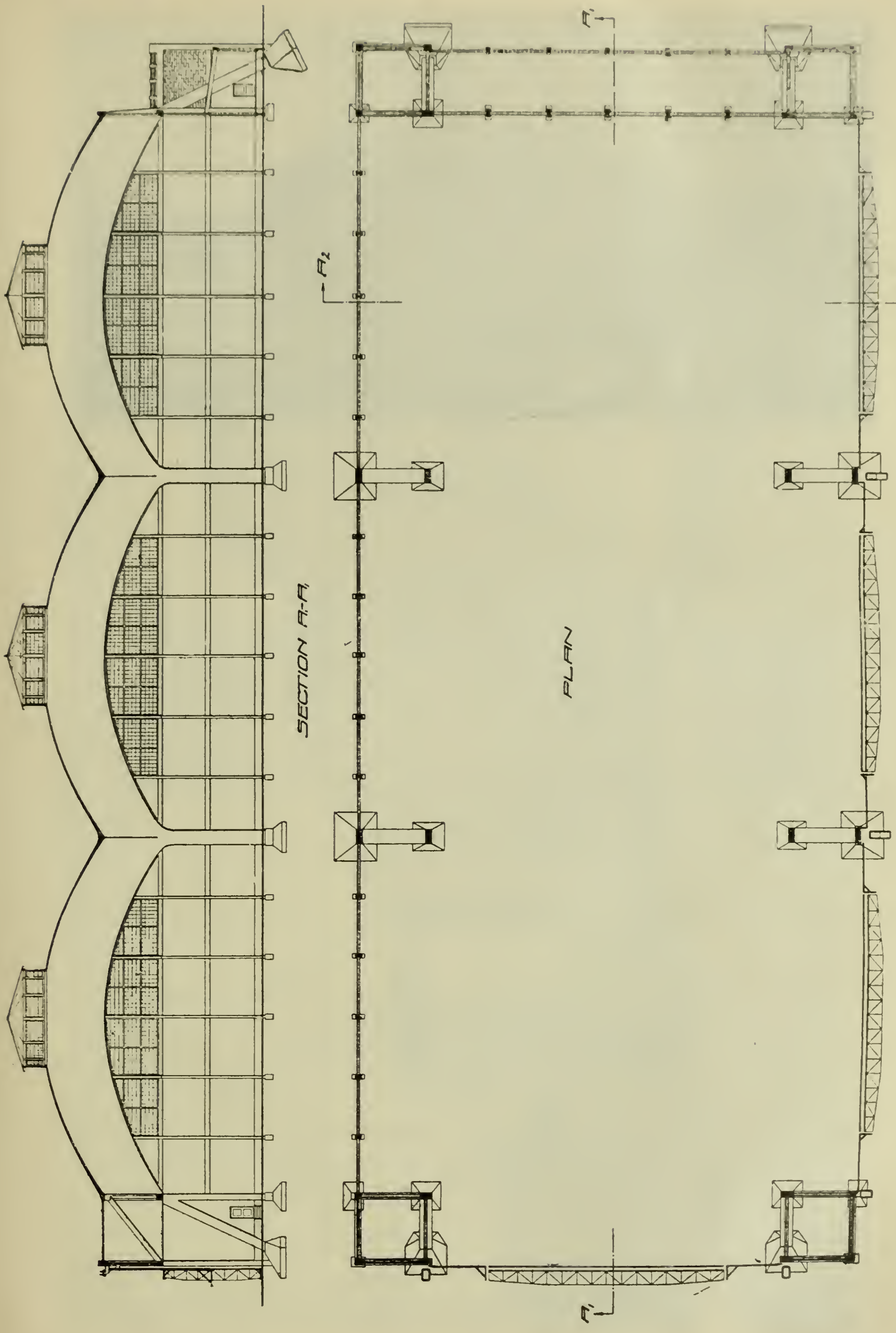
REINFORCED CONCRETE HANGARS.

THE reinforced concrete construction shown in the following pictures is an example of a dome building saving steel and concrete.

The aeroplane hangars were built in 1917 at Reval, Russia, for the Imperial Russian Government. As no pillars were allowed in the interior of the building, the designers had to recur to a dome construction. Each of the domes, which were built over a complete wooden centering, has a clear span of 120 feet. The slab, which is not supported by ribs, has an average thickness of 7 inches. Buttresses on the sides of the building take up the thrust. Each hangar (there are four altogether) has a length of 400 feet and a width of 167 feet. The height is 86 feet.

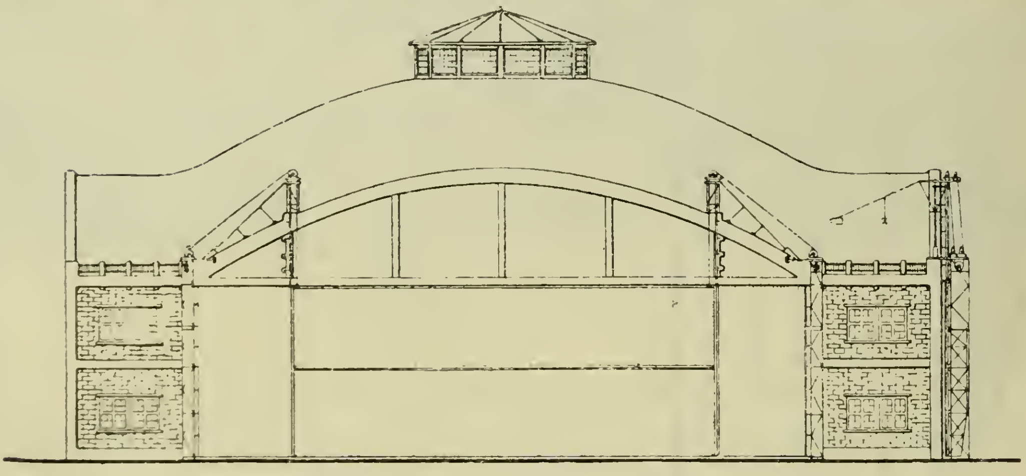
Iron doors, which can be handled by one man, close the hangar on the two sides. These doors are specially designed so as to take up as small a space as possible when lifted.

The hangars and salvage pontoons were designed and executed by Messrs. Christiani & Nielsen, 25, Victoria Street, Westminster, who also designed the doors of the hangars.

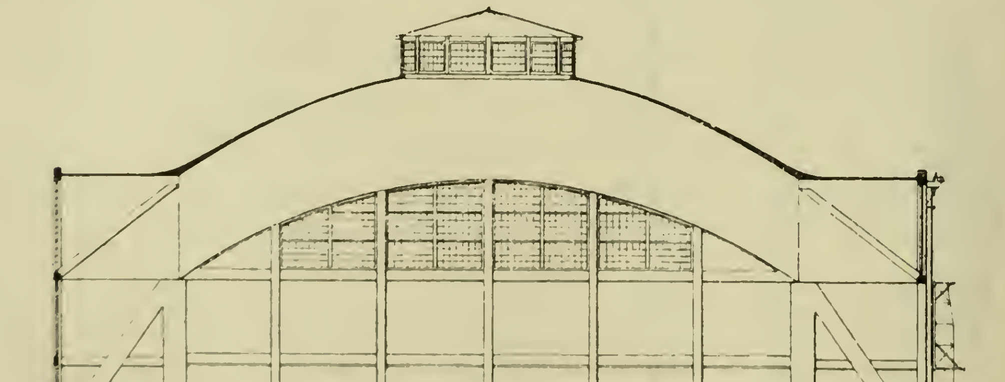


Reinforced Concrete Hangars, Reval.

Hangars in Course of Construction.

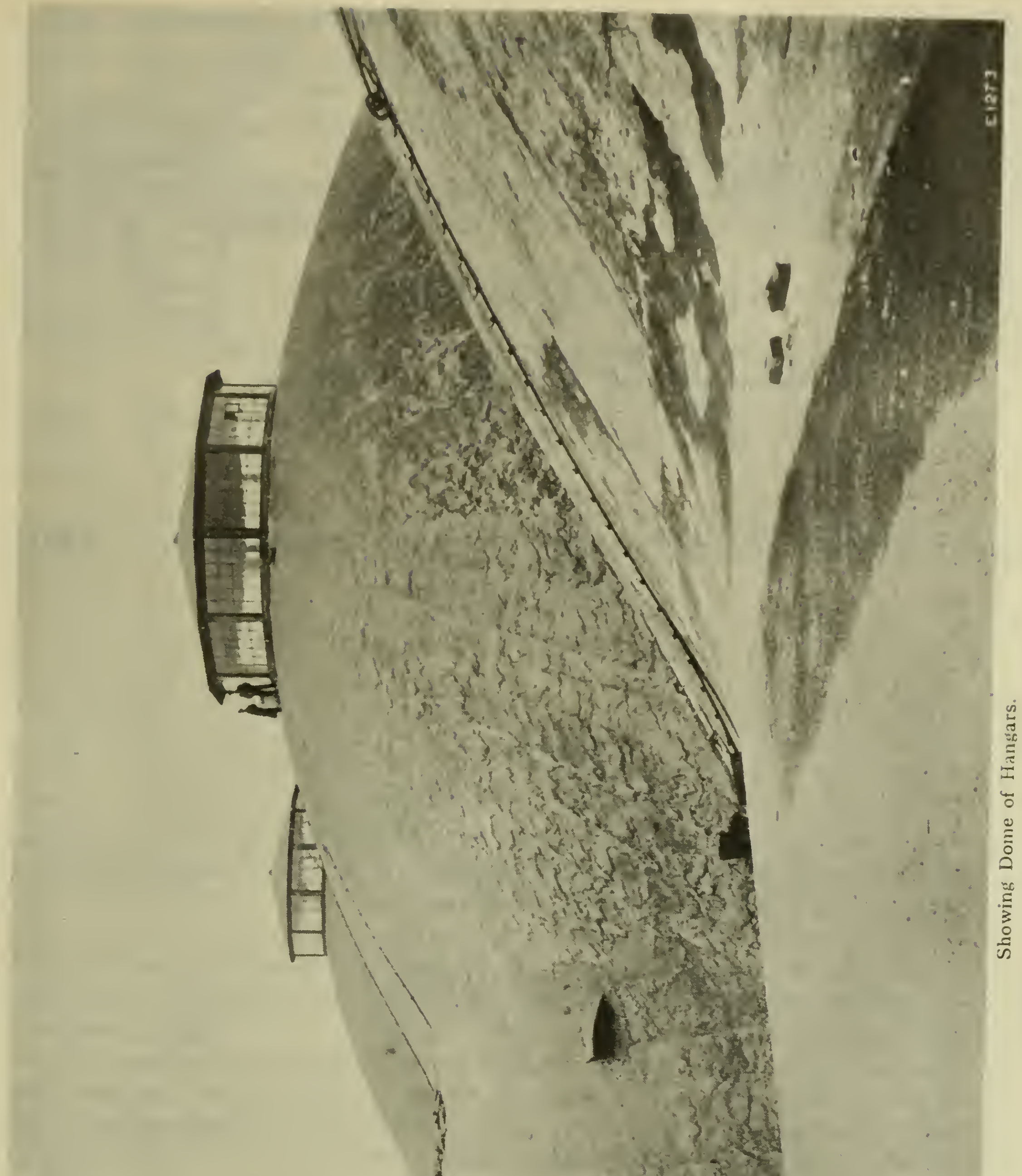


END ELEVATION.



SECTION A_2-A_2

Reinforced Concrete Hangars, Reval.



Showing Dome of Hangars.
Reinforced Concrete Hangars, Reval.

"CONCRETE SHIPBUILDING"

It is our intention to discontinue this series as a special supplement, and to incorporate it in each issue of the magazine.—ED.

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER V.

METHODS OF CONSTRUCTION.

The chief principles which regulate the shape and size of the various parts of a concrete vessel have been indicated in the previous chapter. It is now necessary to describe how the instructions of the designers may be carried out.

Site.—The best situation for building concrete vessels is a part of the country where the climate is warm and damp, and the ideal site is where the ground and foreshore are very hard and firm, in order that construction can be made without piling or expensive preparation, and where launching can take place with simple slipways.

By constructing the vessel in such a situation that she may be waterborne without subjecting her to stresses as severe as those imposed by launching, the necessary period of delay between the completion of pouring and floating is reduced. The advantages of floating from a dock, however simple or elaborate it may be, as distinct from launching are :—

1. The possibilities of failure of the structure during removal from the building berth are much reduced.

2. The number of berths required to execute in a given time any programme is reduced owing to the fact that the number of ships lying " weathering " on dry land is less.

3. The ground can be permanently levelled and prepared so as to form the exterior surface of the bottom shuttering, whereas bottom shuttering is always required (at least in a monolithic vessel) where launching is contemplated.

It should be noted that given equal speeds of construction the time from laying of keel to delivery to owners will be the same under either method if, as is essential, the strength on the maiden voyage is to be the same in both cases.

The choice will be determined by the financial considerations governing the acquisition and development of the building site.

It is very advisable to have the building slipways properly covered over to keep off the rain, and a complete building with sides would be an advantage, especially in an exposed position, as it would keep away the frost and cold.

Cement storage bins should be arranged in a dry shed, the bottoms being well above the concrete floor of the building, and the sides and backs of the bins clear from the side of the building so as to ensure the cement being kept absolutely dry until it is used. The sand and aggregate should be stored in the vicinity of cement storage bins.

In selecting a site and preparing it for building concrete vessels, it is necessary to bear in mind the detrimental effect of frost, strong sunshine, and high winds on the setting or *green* concrete, and to arrange for the vessels to be protected from these previous to their being launched. After the hull is completed and the concrete has begun to harden, atmospheric influences have no considerable effect, though it is desirable to keep the concrete thoroughly wetted for at least a week after it has set to a hard mass.

For the reasons just given, it is clear that temperate and tropical countries are the most suitable for building concrete ships, and that very cold climates should be avoided.

It is also necessary to consider the materials involved. A boat of, say, 1,000 tons capacity will require approximately 40 tons of fresh water, 564 tons of aggregate, 234 tons of sand, 125 tons of cement, 160 tons of steel, and 138 tons of material for equipment in the way of machinery, etc. It is clear, therefore, that the combined weight of the sand and aggregate is 66 per cent. of the total required, including equipment. It would consequently appear desirable, so as to save the cost of freightage and the difficulties of transport, that waterways for concrete ships should be in the neighbourhood of suitable stone quarries, where crushing plants could be put down and trolley-ways or rope-ways for transporting the material from the quarry to the shipyard could be arranged. It is also desirable that cement should be obtainable in the immediate district.

It is very convenient to have the concrete mixers placed above the ships, and the concrete transferred by gravity to each part of the vessel requiring it. (See also *Launching*, Chapter VI.)

Constructional.—Concrete is worked as a plastic material; hence the processes of construction resemble those of the foundryman and plasterer rather than of the shipyard, the concrete being applied in the form of a paste, which is plastered into the reinforcement, or as a thick viscous fluid which is poured or " cast " into moulds and allowed to set and harden.

Mixing the Concrete.—In order to make concrete of a suitable consistency, the selected, washed and graded sand and aggregate should be measured in suitable proportions and a corresponding amount of cement should be weighed, it being usual to assume that 1 cu. ft. of cement weighs 84 to 85 lb.

These materials and the water must be mixed as thoroughly and rapidly as possible, so as to form a thin paste or slurry which can be readily poured around the reinforcement without being unnecessarily fluid.* If the mixing is incomplete, the concrete will be irregular in composition and the various parts of the vessel cannot then be relied upon to possess the requisite strength or impermeability. If, on the contrary, the mixing is unduly prolonged, the setting of the cement will be affected, and a very weak concrete will be produced. For these reasons, it is almost essential to use a power-driven mixing machine which should be arranged as close as possible to the part of the vessel undergoing construction. A mixer of about $\frac{3}{4}$ cu. yd. capacity will be suitable for most purposes, though larger ones may be used for vessels over 600 tons displacement. An ample supply of fresh water, trucks, tipping wagons, and other facilities for rapid working are essential.

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* Special care must be taken not to use too much water or the concrete will be weak.

It is necessary to mix the concrete thoroughly by machinery in quantities that can be immediately used, and to use it as quickly as possible after being mixed, as cement commences to set immediately it is mixed with water ; under no circumstances should a concrete which has been allowed to set be mixed again for use. Each charge, if possible, should be completed in one operation.

About one minute is usually allowed for the actual mixing of the materials in the machine, and if the arrangements are properly organised, charges or batches of concrete can be delivered at an average rate of 20 per hour. It is always advisable to mix the solid materials first, then add the requisite amount of water (about 1 gall. per cu. ft., or 16 per cent. of the weight of the other materials), and to count the time of mixing from the moment the water is added. By this means a more uniform concrete is obtained than when the water is added without a preliminary mixing of the solid materials. No mixing should be permitted during frosty weather.

The consistency of the concrete must be regulated in accordance with the spaces between the reinforcement. If these are relatively large a soft pasty consistency will be satisfactory, but where little space exists between the reinforcing bars a more liquid concrete is necessary. If concrete of different consistencies is used in various parts of a vessel, great care must be taken that it does not vary unduly in expansion and contraction on drying. The more pasty the concrete—provided it can enter properly between the reinforcing members—the better will be the result ; a *stiff* paste should, however, be avoided. When the mass is placed in a mould and *well* tamped or tapped with a wooden mallet, water just sufficient to form a thin film should rise to the surface. A large quantity of water indicates that an excess of this constituent has been used.

The best consistency of a concrete mixture, like that of a clay used by the potter, is easily recognised by men accustomed to working the material, but it is almost impossible to describe it with accuracy or to express the proportions of solid material and water in terms of definite figures.

Shipbuilding.—The methods used in building concrete vessels may be divided into three groups according as the reinforcement is : (i) thickly plastered with concrete (ii) the chief feature of the vessel, the concrete merely forming a thin protective cover for it ; (iii) partially surrounded by a sectional mould, and the concrete slurry is then cast around it, this process being repeated until the vessel is completed ; and (iv) the whole of the vessel is cast as a monolith instead of in sections.

The last method is unquestionably the best, but the others are used where the cost of a single mould is regarded as prohibitive.

(i) *Plastered Ships.*—Many of the numerous river barges and pontoons built in Italy since 1902 consist chiefly of a steel meshwork set to shape and plastered on both sides with cement mortar, very much as a ceiling or a room is plastered on a metallic lathing, and the method has proved successful for small craft which are never strained heavily. Small motor boats or canoes have been built similarly in various countries, including the small pioneer rowing boat in France in 1849 by Lambot (*Fig.* 1), the schooner *Wanderer* (*Fig.* 21), the barges built by C. Weber (*Fig.* 102), the *Antoon* (*Fig.* 7), the German boat mentioned earlier, and Dowsey's motor boat (*Fig.* 20). For heavier craft, and particularly sea-going craft, this arrangement of the main steel reinforcement and concrete does not appear to give a concrete sufficiently strong to meet the stresses imposed upon it. The claims of Weber's Tector process of applying the cement under great air-pressure (similar to his use of the " cement gun,") have yet to be justified.

In a method of plastering patented by D. Wilson (Eng. Pat. 6,530, 1887) the reinforcement is coated by placing a shield or shields on one side at a distance equal to the thickness required for the coating on that side, and then applying the cement or concrete to the other side by means of tools such as are ordinarily used in applying cement or concrete to the other side by means of walls and other surfaces. In this manner the space between the shield and the reinforcement is filled with the cement or concrete which passes through the interstices of the metal, and when the surface is filled the required coating on the open side of the reinforcement is formed by applying a further quantity of cement or concrete to it. Where desirable or necessary the reinforcement may be made and coated in two or more parts.

A small boat built in this manner by P. P. Brannon, of Sonsonate, San Salvador, illustrates the ease with which this method may be used in " out-of-the-way " places. This vessel was built keel upwards on a cemented floor curved to the lines of the boat's gunwales. A core of sandy clay, the shape and size of the interior of the boat, was smeared with wood ashes to prevent adhesion, and the core was covered with a closely fitting skeleton of heavy-woven netting of ½-in. mesh, the sheets being solidly joined with copper rivets. The concrete—a mixture of equal measures of cement and clean river sand—was applied with a trowel, and a retaining wall or shell of damp clay to hold the concrete in position was built as the concrete was placed. The concrete layer was 1 in. in thickness, except near the bilge and keel, where it was 2 in. thick. The boat was floated a month after completion, and later a larger boat, 18 ft. in length, was built in a similar manner ; both were in use for some years.

(ii) *Structural Steel Ships.*—The construction of the hull of rigidly attached bars, on which the designer relies for the whole strength of the vessel, the concrete being merely a protective layer, is unsatisfactory, and its use is a reversion to a method of construction abandoned long ago by users of reinforced concrete for structures on land. As T. J. Gueritte has so ably explained, the use of lattice girders forming the skeleton of all the frames, and also the skeleton of the sides, and encasing this metallic framework in concrete, appears to confer advantages of simplicity and quickness of construction, but there is no appreciable saving in time, and there are very serious defects inherent in this system, such as the impossibility in it of distributing the stresses. By concentrating the metal in parts of the mass instead of distributing it throughout, the concrete will not lend its properties to the steel and borrow some from the latter, and *vice versa* in so complete a manner as in reinforced concrete. In particular, the large cracks so characteristic of ordinary concrete work, and unknown in reinforced concrete, would tend to appear, and this would be a very serious defect in concrete ships. The work would also lose the resilience and elasticity which is so striking a character of reinforced concrete. A rigid framework of this kind, instead of being made of round bars, would require flat bars and small angles ; in fact, structural steelwork of the very kind that is most in demand to-day. It would also require the employment of steelworkers of the very kind one wishes at the present time not to draw upon, seeing that all the steelwork would have to be punched, bolted, or riveted. Moreover, experience has shown that such a method of reinforcement is more wasteful in steel by 15 to 20 per cent. It has also been found in practice that in reinforced concrete work it is most advisable to avoid any sharp angles or corners in the steel work, all such angles being potential starting points of cracks ; and that concrete adheres less easily to comparatively large and flat surfaces, such as presented by angle bars, than to ordinary bars. It may also be added that if, in order to avoid riveting, an attempt is made to use bolts, as the bolt holes will be of greater diameter than the bolts (so as to facilitate fitting up) there will remain throughout the framework an immense number of small recesses to which concrete will not have access ; the steelwork will therefore not receive in those points the protection against corrosion which the concrete should afford it, and such points will be potential starting points of corrosion.

An example of this method of construction is shown in *Fig.* 131.

(iii) *Sectional Moulds* (*Unit Method*).—In this method portions of the vessel are cast separately, and are afterwards united by intermediate portions which are cast *in situ.* Thus, in the construction of river barges in France, the frames and stringers were cast *in situ*, and the wall plates (which had been cast in separate moulds) were set in position between them, so as to be incorporated into the structure during concreting, the bond being given by the ends of the reinforcing bars of the plates, which protrude all round. More recently, the same firm has abandoned the unit method and reverted to casting *in situ.*

The sectional method suffers from a very serious defect—namely, the impossibility of making the reinforcement continuous throughout the length of the vessel. This causes a serious loss of strength unless a very large proportion of reinforcement is employed. Consequently, in spite of its apparent attractiveness it is not, in its present form, very suitable for large vessels.

(iv.) *Single Moulds* (*customary method*).—In this method of construction the shape of the vessel is determined by a large mould built of wood or metal (usually termed the *shuttering*, *centering*, *frame work*, *form work*, *false work*, *etc.*) in which the reinforcement is placed in the desired positions, after which the mould is filled by pouring concrete slurry into it. When the concrete has set to a solid mass the shuttering is removed, and, with care, may be used again for other vessels of the same size and pattern.

There are several modifications of this method of construction which deserve mention :

(*a*) The method used by the Porsgrund Cementstöperi A/S., of Porsgrund, was designed to avoid the use of double shuttering. A core of wood, the shape of the interior of the hull, is built on a sledge laid on the slip ways, and the reinforcement is fixed around it. The concrete is then poured on to the reinforcement (the vessel being built upside down), and the exterior is formed by working the concrete with trowels to the desired shape. In some respects this method closely resembles that use for plastered ships but enables a thicker shell to be produced more rapidly, and avoids the use of wire netting or expanded metal. For shallow vessels of simple form and moderate dimensions this method appears to be feasible, but for deeper ones the sides would require almost as much shuttering as in concrete vessels built in the customary manner. Notwithstanding this drawback, the idea of constructing concrete vessels keel uppermost has appealed to several minds. It is included in an early German patent granted to M. Kreutzer (252,417 of April 25th, 1911), in which a core, representing the interior of the vessel with keel upwards, is covered with the reinforcement, and an outside mould of plaster is then placed over it. Concrete slurry is then poured into the space between the core and the outside mould. A. Lehmann's English Patent (19,961, 1911) is almost identical with this.

(*b*) The whole of the reinforcement may be fixed, as when a single form or shuttering is used, but the sides of the vessel may be formed by means of sliding sections which are moved forward as the casting proceeds. This method is illustrated in *Fig.* 96.

It undoubtedly requires less shuttering than a single form, but the saving in timber and cost of construction is problematical, and the drawbacks are serious.

(*c*) The use of a single form equivalent to the whole of the hull appears to be by far the best method of building concrete vessels of more than 500 tons displacement. The form is made in such a manner that the space between its inner and outer portion is identical with the shape of the hull of the vessel to be constructed. It is true that a large quantity of material is required to construct this form, and that the cost of the labour required for its erection will bear a considerable proportion to the total labour required for the ship. It is therefore an obvious economy to arrange that several vessels shall be cast from the same moulds.

As will be seen on reference to *Figs.* 159, 160, the inner and outer portions of the form are never completed before the concrete slurry is poured into the intervening space. If this were done it would be almost impossible to produce a sound vessel, owing to the difficulty of ensuring that the concrete had completely filled the space between the two portions of the mould. The outer portion is, therefore, completed first, and the inner portion is built up piecemeal as the casting or pouring of the concrete proceeds. There are obvious disadvantages in this method of proceeding, but it has been found the most reliable of any yet tried in the construction of large concrete vessels. There is ample scope for ingenuity in overcoming the difficulty experienced in the use of a mould which is completed before the concrete is cast.

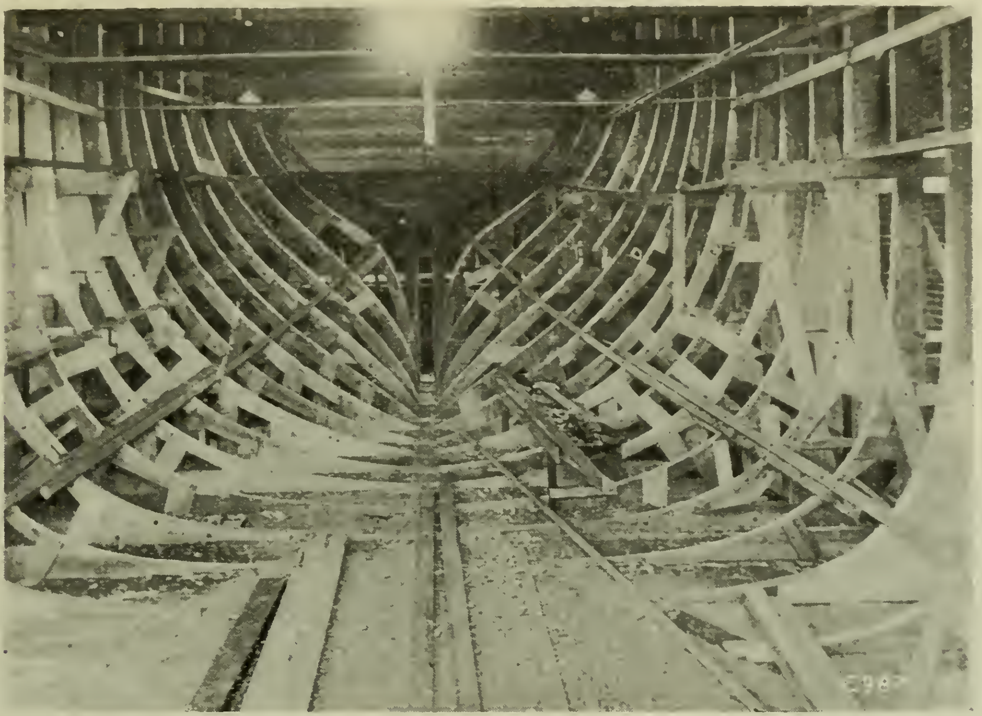

Fig. 159. View of Wooden Ribs, showing the shape of the boat stern. Close boarding is nailed to the ribs to form a mould for the concrete. An outer and inner mould are constructed between which the concrete is cast.

MOULDS AND SHUTTERING.

The forms, moulds or shuttering (*Figs.* 159 *and* 160) used in the construction of concrete vessels are usually built of wood, but this material can only be used for five to eight vessels, and even then requires great skill and care if a heavy charge for repairs and renewals is to be avoided. If a large number of vessels of the same size and pattern are to be built, it would probably be advisable to use a more suitable material, such as cast-iron, or even reinforced concrete, for the form work. The use of thin shields of metal is not satisfactory, as the concrete cannot be tamped properly, rendering it difficult to obtain an impervious structure and necessitating the use of a surface coating.

The form must be built in such a manner that it can be removed piecemeal without jarring the concrete. It must be strong enough to resist the pressure of the concrete (about 140 lb. per sq. ft. for each 1 ft. of height), and the boards used must be jointed in such a manner that no leakage occurs. It is advisable to use planed tongued and grooved boards in direct contact with the concrete as this gives a better finish, and is a better preventive of leakage than plain rough boards. These facingboards must be well supported by other timber, the form being built up in sections so as to facilitate dismantling and reassembling.

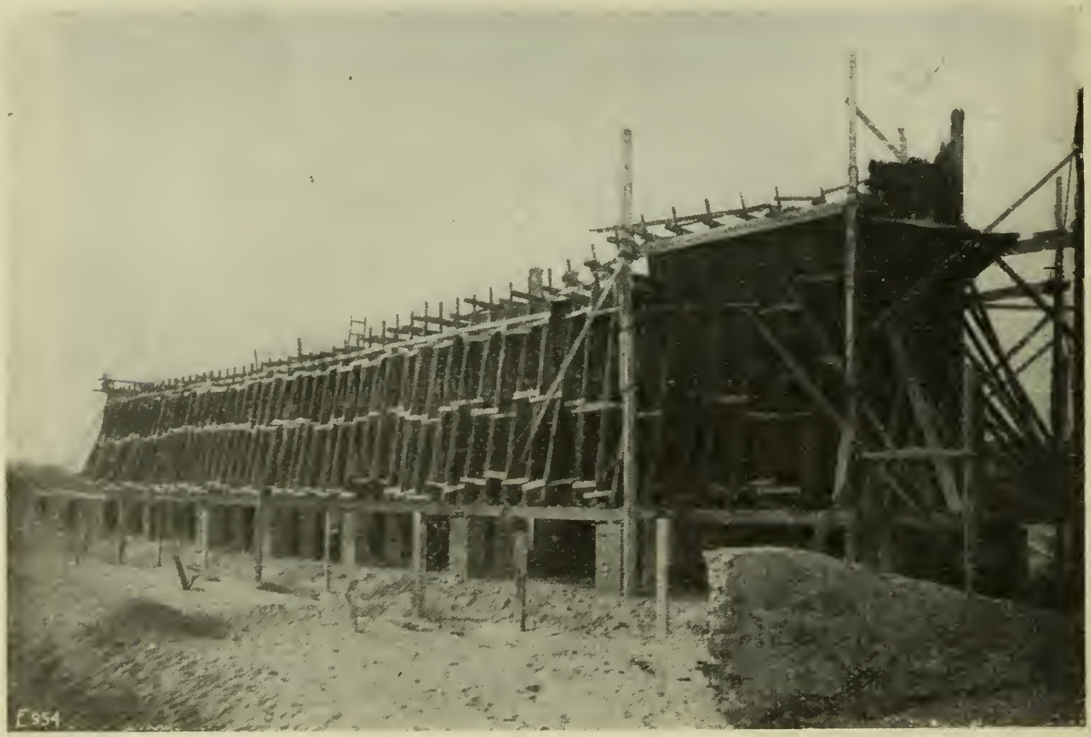

Fig. 160. Shuttering of Concrete Vessel.

The construction of the form requires great care, as mistakes cannot be remedied. The space inside should also be kept clean, any chips, etc., being removed at once. Where possible, the shape should be such that the angles of the concrete are rounded.

The essential characteristics of good forms are rapidity and ease of construction, great stability in use and rapidity and ease of removal without tearing or jarring the concrete.

The wood should be wetted before pouring in the concrete, so as to prevent the adhesion of the latter. Unless this is done some of the concrete will be torn away when the forms are taken down. For special work the forms may be lime-washed, oiled or coated with soft soap. Creosote and kerosene oil are useless, but linseed and black or cylinder oils are excellent. Even when oil is used, it is desirable, just before pouring in the concrete, to flush the form with water.

Some shipbuilders prefer to coat the forms with paraffin wax—an excellent though somewhat expensive material.

PLACING THE REINFORCEMENT.

The various bars, netting, or other reinforcement, are placed in the required position and fixed there by clips, wire or even by welding. The latter is by no means as desirable as is sometimes supposed. The hard concrete is the chief medium for holding the metal in position, so that there is no object in fastening it more tightly than is required to hold it during the placing and setting of the concrete.

In placing the reinforcement, the first operation in every case is the erection of framework and the outer side of the moulds for the concrete shell of the hull. While these are being formed the bars and other members of the reinforcement are cut off, bent, and otherwise prepared in accordance with the working drawings. As soon as the shuttering is sufficiently advanced, the reinforcement for the bottom and sides of the hull, for the transverse frames and for the bulkheads is assembled in position and securely fixed, so that there will be no possibility of displacement during the placing and tamping of the concrete. The moulds for the horizontal portion of the transverse frames are completed before the concreting is started, while the inner shuttering for the hull and the moulds for the vertical portions of the frames are built up as the concrete is placed. Similar methods are adopted in the construction of the decks, hatchways, boiler house, coal bunkers and other interior accommodation. Sharp corners should be rounded where possible and sudden bends avoided unless essential.

PLACING THE CONCRETE.

The operation which in the metal industries is known as *casting*, and in the plastic industries as *moulding*, is, in concrete construction, termed *placing*. In each case it is the operation which gives the material the shape which it is desired it shall possess.

The outer or inner part of the form should be erected, according as the vessel is to be built keel downwards or keel upwards, the reinforcement is then placed in position and sufficient of the other part of the form to make a good casting is then added. Small distance pieces of concrete may be placed in such positions as may seem desirable. Sufficient freshly mixed concrete slurry is then poured into the completed portion of the mould. There should be no delay between mixing and placing the concrete, or the consequences may be serious. It is, therefore, wise to mix the material in only small amounts, and on no account to use concrete which has begun to set. A slow setting cement should be used when the concrete has to be taken a considerable distance from the place of mixing to where it can be poured into the forms. The concrete paste may be handled and " placed " in any convenient manner, provided that it does not begin to set before it is in position and that no un-mixing of the material occurs. Wherever possible the concrete should be shovelled direct from the mixing board or machine into the forms, but where large quantities are required it is usually necessary to transport it in barrows to that part of the structure where it is required.

In order to render the concrete as dense and compact as possible, a vertical tool resembling a spade may be inserted close to the inner faces of the form and worked up and down, so as to push the aggregate away from the form, release any air bubbles and produce an even face. The size of the spade will depend on the space into which it is introduced ; a long board 4 in. by 1 in., sharpened to a chisel edge, is exceedingly useful for this purpose, though for broader work an ordinary spade may be used. Spading in this manner needs considerable skill if a dry concrete mixture is used ; with a very sloppy mixture, on the contrary, no such treatment is needed though it is, in all cases, a wise precaution. A ram or tamping tool (*Fig.* 43) is then held just above the top of the concrete layer and is brought down into it in a succession of blows until all the material is compact and the surplus water has risen to the surface. Hard ramming is seldom necessary with a well-made concrete, though the drier the mixture the harder must be the blows. Indeed, very heavy blows tend to do more harm than good, what is required being a series of tamps or taps of just sufficient force to secure the various particles all fitting into their places without leaving any voids. Many light taps are far more useful than a few heavy ones in consolidating the concrete. Some firms prefer to use a wet mixture and not to tamp at all, but to rely on the natural fluidity of the concrete, aided by the use of a special spade. Vibrators—operated in a similar manner to pneumatic hammers—are applied to each side of the form or shuttering by the Vibrocel Co., Ltd. This special mode of tamping is claimed by the patentees to give a more impervious concrete than is obtainable by any other method. The resumption of placing (after an interval) and the attachment of new concrete to old is also greatly facilitated by vibrating instead of the more usual tamping.

If the work of placing the concrete is suspended, all necessary grooves for joining future work must be made before the concrete is set. When the placing is resumed, the previous concrete must be wetted, roughened, cleaned of all foreign material, and covered with mortar, consisting of one part of Portland cement with not more than two parts of sand, so as to form a layer of mortar half an inch thick. Care should be taken that the joints of this kind are made in positions where they will have the least possible effect on the strength of the structure.

Thus, when a section is stopped either for a meal-hour or for the day, the surface should be made rough by the tamping tool or other means, some preferring a longitudinal groove as well. Before continuing, the surface should be damped well and coating with half an inch of cement mortar to ensure good jointing. The efficiency of the work depends largely upon the careful casting, and if at all possible continuous work is to be preferred, to ensure homogeneity.

In tamping the concrete, which must be done thoroughly to increase the impermeability to water, care must be taken not to displace the steel reinforcement. The tamping is also necessary to get good adhesion to the bars.

As the strength of the vessel will depend largely on the care and skill exercised in placing the concrete, this part of the process of construction should have all the attention it needs.

When one portion of the vessel has been cast or placed in this manner, additional formwork is added so as to enable a further portion to be placed. In order to secure a truly monolithic structure, the placing should proceed as rapidly and continuously as possible, the formwork being designed to facilitate this. Unfortunately, it is seldom possible to make the placing a continuous operation in any but the smallest vessels and, in practice, large areas are allowed to set before further placing is effected. The need for caution in securing good joints between the new and older portions can scarcely be over-emphasised and no pains should be spared to remove all traces of jointing, as far as possible, by damping the old surface and applying a cement grout before placing a fresh portion. Care should also be taken to "stagger" the joints so that they will not be in one straight line.

The extension of the formwork and the pouring of the concrete, together with the necessary tamping and other precautions, are continued until the formation of the hull is completed.

CONCRETE ROADS.

Under this heading we present various items of recent news relating to concrete roads.—ED.

AMONG various questions which came up for discussion at the Conference of Municipal and County Engineers, recently held, it was to be expected that the matter of roads and highways would be dealt with at considerable length. Among the papers read was one by Mr. H. T. Chapman, county surveyor, Kent, entitled "The Task Confronting Highway Surveyors." Needless to say, the concrete road came in for a considerable amount of discussion and a section of Mr. Chapman's paper was also devoted to this side of road construction. We give below Mr. Chapman's remarks on the matter, and also that part of the discussion—as far as we were able to procure it—which had bearing on this particular part of the paper read. Readers will note that the use of concrete for road work was criticised both favourably and adversely. But, with regard to Mr. Wakelam's remarks, we think it well to point out that in America concrete for road construction is finding increasing favour. Engineers in that country are giving much time and thought to the matter, and by the aid of numerous experiments and tests are constantly finding means and ways of improving upon the earlier methods adopted. Regarding cost of maintenance we think the figures we quote below as to the cost of maintenance on certain types of road in New York for the period January, 1915, to December, 1918, speak for themselves.

We would, at this point, also draw the attention of our readers to some interesting tests undertaken by Mr. Eltinge Breed, engineer, New York, regarding the testing of concrete aggregates for road work. (See page 453.)

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.

CONCRETE ROADS.

An Abstract from a Paper read by Mr. H. T. Chapman, County Surveyor, Kent, entitled "The Task Confronting Highway Engineers."

On the subject of concrete roads, he said that he laid some experimental sections in conjunction with the Road Board on the London-Dover main road near Gravesend between December, 1914, and March, 1915, and although the results could not be said to have been as successful as was to be hoped, the experience gained was certainly most useful. The carriageway was surfaced half at a time, and during the laying of the second half width the whole of the traffic, amounting to over 1,000 tons per twenty-four hours, was concentrated on the first half, which was rapidly pulverised, and disintegrated to a depth in places of up to 2 in. in the wheel tracks. In view of this it was decided to lay a portion of the second half in 6 to 1 concrete to a thickness of 4½ in. and to top the same with 1½ in. of 3 to 1 fine concrete. The 6 to 1 concrete could not be said to have proved satisfactory or suitable, but that portion which was topped with the 3 to 1 material was practically as good as when laid, and there were no signs of disintegration or cracks. Mr. Chapman was of opinion that provided all vehicular traffic could be kept off the surface for a month after completion 6 to 1 concrete might be laid 6 in. thick to carry moderate traffic successfully, and that it might be adopted for new roads and *in lieu* of paving in some town streets carrying slow if heavy traffic For heavy traffic, numerically and individually, it was necessary to provide a surfacing of 3 to 1 concrete at least 1½ in. thick on the 6 to 1 concrete. In all cases reinforcement was desirable to carry heavy loads and prevent surface cracks.

DISCUSSION.

Mr. J. A. Brodie (Liverpool) who opened the discussion, thought more attention ought to be paid to concrete than had been the case in the past. Just before the war he decided that he could put down concrete roads quite as cheaply as ordinary macadam roads, and it was done by utilising destructor clinker. An advantage of concrete construction was that it was possible to get a perfectly true surface, and one over which one could travel at a high speed without any difficulty and without injuring the road. He strongly recommended that attention should be paid to the use of concrete for the lighter class of roads which would be required in connection with the proposed housing schemes. If one put down concrete roads of proper section and under proper conditions and tar sprayed the surface with a suitable substance one ought to get a cheap road ; and if the concrete was properly handled one ought to get a road that was true and economical in maintenance.

Mr. H. T. Wakelam (Middlesex) said that Professor Blanchard, professor of highway engineering at New York University, with twelve or fourteen other members of the university, had recently written a book on roads, and that they were to a very great extent opposed to the construction of concrete roads. The troubles common to concrete roads due to cracking, expansion, reinforcing and atmospheric changes made it a very uncertain thing to adopt. It took too long for the concrete to mature, and it was not always possible to divert traffic. Concrete, however, might be adopted for side and light traffic roads.

Mr. F. W. Bricknell (Hull) said the temptation to use destructor clinker was strong, but he had been assured by contractors that it was such " hungry " stuff that while they might save in one way they would lose in another. It seemed to him that when asphalte became cheaper it would permit of the construction of a much cheaper road than any permanent road they knew of at present. He was anxious to find a way of using natural asphalte in an inexpensive form, and employing it with destructor clinker. Personally he had a dislike for tar macadam. The tractive effort required was greater than on water-bound macadam, and he had always succeeded in holding together his macadam by tar-spraying.

Mr. M. Jones (Chester) said he was convinced that concrete roads were a cheap class of construction with enormous possibilities. In connection with a housing scheme at Chester, the estimated cost of a concrete road 6 in. thick was 10s. 6d. per super yard, while to do the same thing in water-bound macadam, including a rock pitch foundation 9 in. thick, would cost 14s. 6d. per super yard. When his estimate was sent to the Local Government Board the question was asked why such expensive roads were being laid in connection with a housing scheme, and he replied that he did not think the Board really understood the question of reinforced concrete roads as it ought to do, and he forwarded his figures. He also told the Board that he was prepared to guarantee a ten-years life for a concrete road before it would require resurfacing, against a life of from four to five years for a water-bound road.

Mr. H. F. Gullan (Belfast) inquired how repairs to concrete roads were to be effected. Was it possible to make a joint with the old concrete by placing a layer on the top?

MEMORANDA.

Good Roads on Long-Term Bonds.—New York State has recently had a change in its highway administration, and with it has come a change in highway policy. The former administration, against the advice of its engineers, leaned, latterly at least, to the construction of a large mileage of cheaper type of highway. The object, if one may put it so, was political rather than statesmanlike—the desire to satisfy the clamours of the populace rather than to give them that which the State's own experience had demonstrated to be the most economical in the long run.

Furthermore, under the New York law the State assumes responsibility for maintenance and rebuilding, once it has taken over a road. It is to the interest of the local community, therefore, to get as much mileage as possible. If that mileage be constructed with a surfacing that wears out in four or five years, or less, it is no concern of the local community, except in so far as it contributes to the general State tax levy. It is a bad business procedure for the State, however, not merely because the maintenance cost of heavily travelled roads is high, but because the State highways are financed by fifty-year bonds, and with a continuance of this procedure issue upon issue would be piled up to pay for surfacings that had disappeared.

The figures in the New York case are very convincing. In the period from January, 1915, to December, 1918, the maintenance on 284 miles of brick road cost $210 per mile per year; on 208 miles of concrete roads, $138; on 2,793 miles of bituminous macadam, penetration method, $490; on 2,451 miles of water-bound macadam, $911, and on 173 miles of gravel macadam, $843. All of these figures are for the maintenance of surfacing without the reconstruction of more permanent or expensive types.—*Engineering News-Record.*

Concrete Paving.—Our American contemporary *Concrete* states that concrete paving this year in the United States will reach unprecedented totals. It is announced that the yardage under contract on April 12th was 5,361,843. One week later this figure had been increased by 1,500,000 yards. The contracts increased from week to week until on May 10th the contracts let for the week slightly exceeded 2,500,000 sq. yds. The total figures on May 10th this year compare with previous years as follows:

	Sq. yds.
1916	8,200,000
1917	7,700,000
1918	6,400,000
1919, to date	12,199,199

TESTING AGGREGATES FOR CONCRETE ROADS.

By H. ELTINGE BREED, Consulting Engineer, New York City.

The following article is reproduced from ENGINEERING NEWS RECORD.

GOOD concrete depends on the quality of the materials—cleanness, hardness, toughness, gradation and proportioning—combined with placing and curing. Methods of testing concrete for road use, chief among which are those for abrasion and impact, are important. Impact tests are by far the most valuable in determining wear-resisting value. Results obtained from a large number of tests made by the New York State Highway Department, with a special machine, seems to justify several conclusions, as follows : (1) Crushed stone concrete resists impact better than gravel concrete ; (2) large-sized materials are more durable than those of small size ; (3) toughness is a very important factor in aggregate ; (4) the fine and coarse aggregate must both be good, and (5) coarse-grained sand mortar resists impact better than mortar made from fine sand.

First in importance are the materials used ; they determine the quality of the pavement. The fine aggregate should be tested for : (1) organic impurities, by the colorimetric test ; (2) gradation (sieve analysis) ; (3) mortar strength, by testing briquettes ; (4) volume of silt or loam by measurement. These are all field tests, except the third, and are very valuable.

The coarse aggregate cannot be tested in the field. Field determination of these materials can be made only for voids. Visual inspection should, of course, detect soft material and dirty aggregates. Such inspection should be made constantly, to know that the material is running uniform and of quality equal to the original sample.

For laboratory test of coarse aggregates, the most valuable is the Deval abrasion test. It is in general use and has been standardised. How accurate it is in determining the suitability of coarse aggregate for concrete roads remains to be seen. It is certain, however, that this test indicates the difference between poor and good stone ; and, taken in conjunction with the impact test, described later, it is the best means we yet have of determining the suitability of stone for concrete roads.

PARTIAL RECORD OF IMPACT TESTS MADE BY THE NEW YORK STATE COMMISSION OF HIGHWAYS.

Coarse Aggregate.	Fine Aggregate.	Mix.	No.	Grammes Lost per Test.	Average Loss.	Remarks.
Trap	Sand, Niagara	1 : 1½ : 3	3	150–110	103	Small stone area omitted.
				105–95		
Trap	Sand, Cowbay	1 : 1½ : 3	4	110–120	110	
				110–100		
Trap	Sand, Albany	1 : 1½ : 3	4	140–110		
				125–125	122	
Trap	Sand, Long Island	1 : 1½ : 3	2	120–135	127	
Trap	Sand, Marlborough	1 : 1½ : 3	2	130–135	132	
Trap	Tailings, graphite	1 : 1½ : 3	2	155–135	145	
Trap	Sand, Booneville	1 : 1½ : 3	4	165–130	149	Group (1) 103–165
				165–135		
Trap	Tailings, iron ore	1 : 1½ : 3	5	200–155		
				165–155	164	Excess grout omitted
				165–180		
Trap	Sand, Cowbay	1 : 2 : 4	2	150–150	150	Group (2) 150–175
Trap	Sand, Albany	1 : 2 : 4	3	180–160	175	Small stone area—excess grout omitted
				185–225		
Trap	Sand, Marlborough	1 : 2 : 4	2	180–170	175	
Syenite	Sand, Booneville	1 : 1½ : 3	8	150–145		
				150–140	141	Group (3) small stone area omitted 141–186
				145–125		
				185–130		
Syenite	Sand, Booneville	1 : 2 : 4	4	180–205		
				180–180	186	
Buffalo Limestone	Sand, Niagara	1 : 1½ : 3	5	150–120		
				155–125	137	Group (4) 137–170
				135		
Buffalo Limestone	Sand, Cattaraugus	1 : 1½ : 3	5	155–160	135	
				140–125		Excess grout omitted
				160–200	148	
Buffalo Limestone	Sand, Booneville	0 : 1½ : 3	4	180–160	171	
				185–160		

Tests for pebbles (called gravel by some) with the Deval machine have been unsatisfactory, because certain pebbles much inferior in service to trap and syenite rock show less loss when tested than do these standard materials. In 1915 the New York State Highway Department laboratory modified the Deval stone-abrasion machine by substituting a slotted cylinder for the closed cylinder. The slots allow the fines to escape, so there is no protective cushion of dust to keep the pebbles from wear. For four years we found that this machine has given slag and pebbles a truer rating in accordance with the service test, though often at variance with the showing of the standard cylinder.

After testing the aggregates, we made tests of the resulting concrete, for two purposes: (1) To determine its wear; (2) to determine its strength.

By far the most valuable test to determine the wear-resisting values is a machine which generates impact stresses, closely paralleling those imposed by traffic. In general, the machine consists of an arm which is raised by a cam and falls freely, striking a 6 in. concrete cube or cylinder upon a table which is revolved by a dog attachment. At the head of the arm are placed nine hitting points, armoured with nonslip horse calks, each point and its shaft being held in place by a spring giving a play of ½ in. to compensate for any irregularity or unequal wear. The effective weight of the head is 29 lb., and the blows are delivered at the rate of 100 per minute. The blows of the calks strike in nine concentric circles ¼ in. apart.

The results of the tests made indicate that generally the average loss increases as the mortar strength of the sand decreases. An average loss for each test shows that there is greater strength in the 1 : 1½ : 3 mix than in the 1 : 2 : 4 mix. It is interesting to note that syenite, with a French coefficient of 12·5 shows, approximately. an equal loss under this test with Buffalo limestone with a French coefficient of 7·9, On the basis of the Deval test, the limestone is inferior for road purposes to the syenite, but service conditions indicate that the Buffalo limestone and many other limestones, with a French coefficient of 7 and better, are very satisfactory, in service.

In the test to indicate strength, concrete from a batch is made up on the road into 6 in. cubes, or 6 by 12 in. cylinders for every 500 cu. yd. or less of material. They are cured for twenty-one days in moist sand and then shipped into the laboratory and tested at twenty-eight days. The following is a record of four years' work:

Years.	Mix.	Coarse Aggregate.	No. of Cubes.	Average compression per sq. in.
1915–16	1 : 1½ : 3	Stone	1,684	3,590
1917–18		Gravel	221	2,950

It may be noted that a total of 1905 tests were made, and that, with the exception of the gravel, they are well over 3,000 lb. per sq. in. When any individual test shows below 3,000 lb., a thorough investigation was immediately made to determine the cause. While this occurred too late to correct the given piece of work, it had a good moral effect on the contractor, and a wholesome rivalry was inspired among the engineers to have a high test value for their work. The figures given above represent actual tests from the laying of something over 400 miles of 16 ft. concrete pavements of 6 in. average thickness.

A CONCRETE VASE MODELLED IN CONCRETE BY MEANS OF TEMPLATES.

CONCRETE STONE MANUFACTURE.

A Review.

By ALBERT LAKEMAN, M.S.A.

In view of the growing use of pre-cast concrete units, the following article, which is a review of a book recently published in America, may prove useful and of interest to those in this country who have given special attention to this form of concrete construction.—ED.

INTRODUCTION.

THE use of concrete has developed so rapidly during recent years that it is employed in almost every building that is erected and it can be applied to practically any feature of a structure, and therefore it is essentially one of the most important materials with which the architect and engineer has to deal. The advantages and disadvantages of concrete have been the subject of many discussions and articles, but the fact remains that it has continued to develop, both in its adoption and its quality, and in addition the conditions prevailing during the war practically forced designers to adopt reinforced concrete in many instances owing to the impossibility of getting sufficient supplies of timber and constructional steelwork for urgent work.

One of the most important developments of recent times, however, has been that of using pre-cast units in place of concrete *in situ*, and this class of work is worthy of study in view of the great possibility of its extensive use in the near future. Some interesting information is given in a volume on concrete stone manufacture* by Harvey Whipple, which has just been published, and as the subject is of such importance at the present time extracts and illustrations are given here, together with additional notes which may be of assistance to those who are considering schemes in which pre-cast units may be employed.

n the preface the author truly states that the development of factory-made concrete units has not kept pace with the development of field-made concrete in mass, and yet factory conditions are obviously more easily controlled than field conditions and standardisation of factory methods and of factory products should, therefore, be the more readily attained. The development in this country has been almost entirely on the lines of units made on the site in the vicinity of the buildings, and thus it differs somewhat from actual factory-made units, but a certain amount of work is being done by firms who specialise in particular types of units, which are made in their own factories. The supervision of pre-cast work is much easier to carry out than with *in situ* work, less timber is required for forms and, generally speaking, less time is required for the erection of the structure as the units can be made during the time required for the foundation and site work, and no delay will be occasioned by the need of waiting for the setting of the concrete and the removal and re-erection of the forms. The work can also proceed during inclement weather as protection can be provided in a simple manner when the mixing and casting are being executed at one spot at the ground level. Unfortunately a large amount of defective work has been done in the past by incompetent persons who have been tempted to commence the manufacture of blocks and other units because the only assets that appeared to be necessary were some gravel, a block machine, a shovel, a little cement and some water, and this has been a great bar to the progress of concrete unit manufacture, because prejudice created by defective work has had to be overcome and the competent manufacturer has had to enter into unfair competition with unscrupulous makers.

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* *Concrete Stone Manufacture.* By Harvey Whipple. Detroit: Concrete-Cement Age Publishing Co. 318 pp.

Materials.—The author of the above-mentioned volume gives some useful notes on the question of selecting a location for a concrete stone factory, and these are followed by some general information on the materials and methods of grading and mixing. The question of the quantity of water required to produce the most satisfactory concrete is discussed at some length, and examples are given to show that the quality falls off very rapidly if more or less than the ideal quantity is employed. Certain experimental work described by Professor Duff A. Adams is quoted, when the conclusion was reached that thechief advantages of well-graded and coarse aggregate, as compared with poorly graded aggregate, come from the fact that the concrete can be mixed to a workable plasticity with less water, and not to any inherent difference in the behaviour of aggregate of different sizes. In other words, while coarse, well-graded aggregate is highly desirable, little or nothing is gained by using aggregates of the highest grade unless we take advantage of the fact that it can be mixed with correspondingly less water. This makes it apparent that many of the shortcomings of concrete made of fine or poorly-graded aggregate should be charged to the additional water required to mix the concrete.

While the greatest fault found with the dry-tamp method of manufacture is the limitation which is placed upon the quantity of water used in the mixture the fault is not necessarily so serious as the products manufacturers themselves have made it. The block machine operator prefers a dry mix. It is more easily manipulated and upon being released from the mould immediately after tamping or pressing it slips away from the mould more easily. If made too wet the moulded product will not stand up. Yet much more water can be used than is used, in most cases without a sagging in the product. It is a matter deserving of the closest supervision until operators can be made to use a wetter mixture, even at some sacrifice of quantity of output. As for the sticking of the facing to the plate, it has been found that while a mixture of a certain degree of wetness is more apt to stick than a mixture a little more dry, it has also been found satisfactory by some to use a little more water instead of less.

Units and Equipment.—A chapter is devoted to standard building units and the equipment to make them, wherein the possibilities of the manufacture of simple standard types is discussed together with the alternative scheme of producing all known classes of goods from the common walling block to special units having some architectural appeal. Also, the relative merits of making the units in tamp machines, pressure machines or with a relatively wet concrete in gang moulds are considered, and it is stated that either system will produce satisfactory work if the method of supervision and execution is efficient. Various machines are described and illustrated, and the different forms of blocks are given together with some notes on structural and roofing tiles. Concrete brick manufacture is also dealt with, and there certainly appears to be insufficient attention paid to this branch of concrete work. When used for walling which is to be left exposed, without stucco or roughcast, as in some classes of cottage work, a better appearance is obtained by the use of a small unit, as the scale is better and for chimney breasts, beam filling and similar positions bricks are more adaptable. It is quite a common occurrence to find clay bricks introduced for various odd purposes in what is otherwise a concrete structure, and this is caused by the lack of a small concrete unit which could easily be produced at small cost.

Lay-out and Operation of Factory.—The importance of the general lay-out of a concrete unit factory cannot be over-estimated, as the supervision, output and cost of manufacture will all be influenced by this factor. The principal moulding equipment is the pivot of the operations and it is necessary to centralise this in such a manner that there is a continuous flow to and from the machines without any possibility of congestion in the transport of the raw materials or finished product.

The operations can be divided roughly into the following: (*a*) receiving and storing of raw materials; (*b*) bringing materials together and mixing with water; (*c*) depositing and moulding the concrete; (*d*) transporting the moulded units to the curing ground or chamber; (*e*) removal of the product to the storage yard; (*f*) the treatment of the surface when specially required. The last-mentioned may, of course, be dealt with to some extent in the execution of the other operations, but it may also become an independent operation, as when the surface is scrubbed with a solution after moulding, or tooling, or polishing are resorted to. The various operations are dealt with by Mr. Whipple in a comprehensive manner, and he then proceeds to give examples of the complete lay-out and plant for factories of different types and sizes, with illustrations. It is impossible to deal with the whole of these in this article, but one example is here given as a specimen of a typical arrangement (*Figs.* 1 and 2). This factory is 130 ft. 10 in. long by 82 ft. wide and is built with 8-in. concrete block walls, concrete floor and concrete block partition walls, with a turret construction lengthways of the building to give ample light and ventilation.

At one end of the plant on the railroad side are the bins and platforms where Portland cement, white Portland cement and white sand are kept, as well as waterproofing material. The bins and platforms are on such a level that the materials are conveyed by wheelbarrow from the car along a level runway to their storage space. Ordinary Portland cement is piled up in bags. White Portland cement is kept in barrels and the white sand, used chiefly for facing, empties from its bin through a spout to a bucket on the floor of the mixing room.

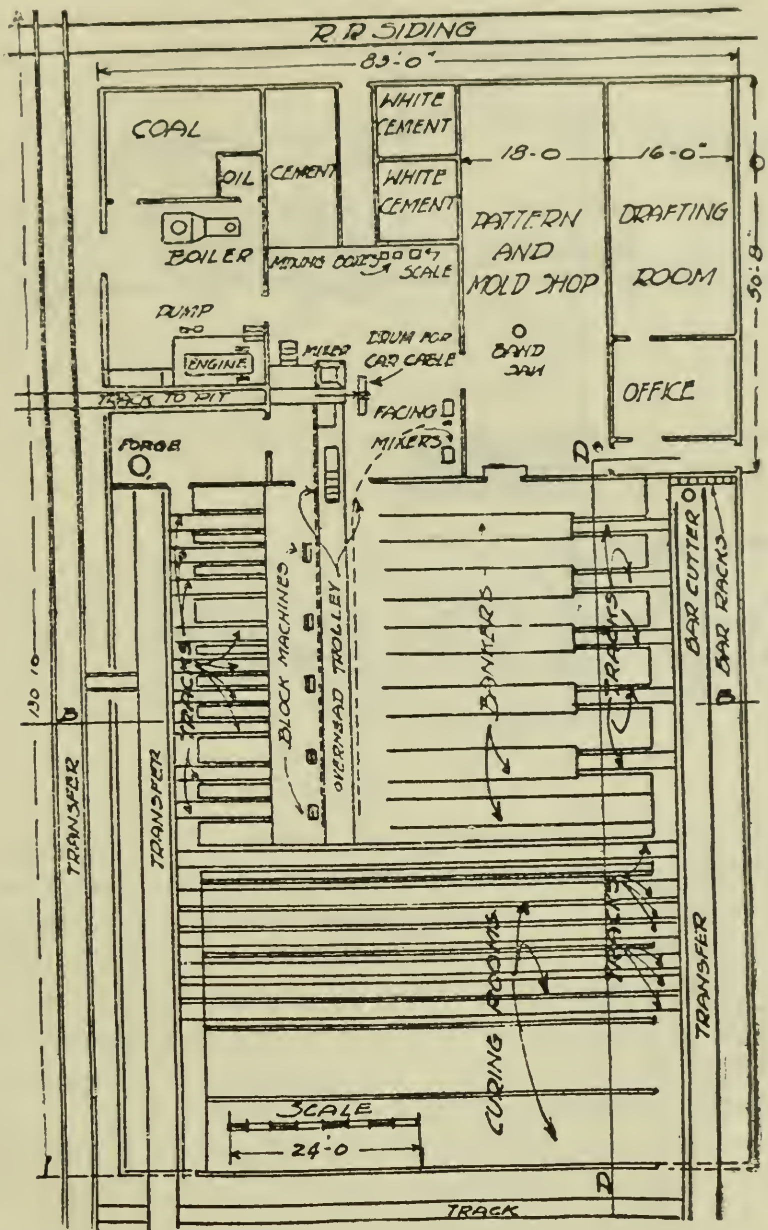


Fig. 1. Plan and Lay-out of a Concrete Stone Factory.

A special hopper has been constructed on the continuous mixer with a small platform on the side toward the storage platforms. A plank is thrown across from mixer platform to cement platform and the cement is carried in bags and dumped into the hopper from which it feeds as wanted to the mixer. At right angles and extending out to the back of the plant is an inclined track on which a dump car with a capacity of 14 cu. ft. runs from the gravel bank direct to the hopper with the aggregate. The car is hauled up the track by means of a hemp cable on a drum on the side of the mixer opposite from the bank. From the two small batch mixers, which provide the facing mixtures, and from the large mixer are overhead trolley rails extending into the moulding room. Suspended from these rails is a trolley and bucket to hold 5 cu. ft. of concrete. The power is supplied by a 25 h.p. engine, and a concrete tower tank holding 42 barrels of water with a 28-ft. head is provided at a convenient point.

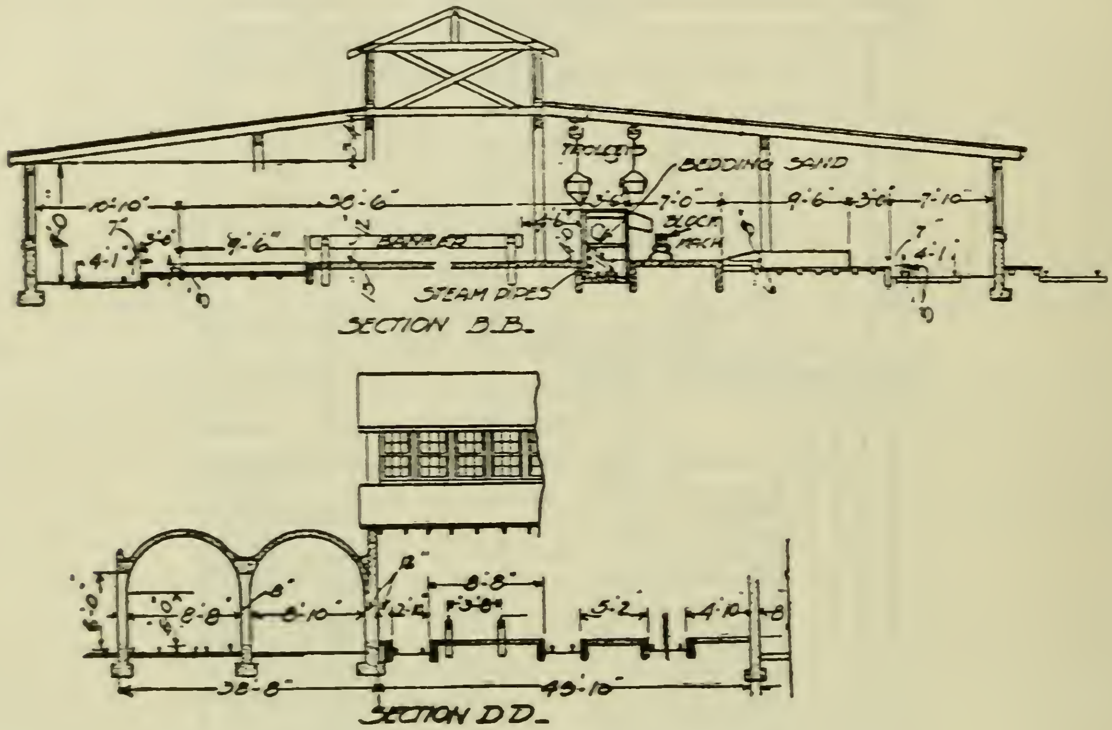


FIG. 2. SECTION OF LAYOUT SHOWN IN FIG. 1

The moulding room is shown in the plan and it will be seen that about two-thirds of the space is taken up by bankers and car pits for specially moulded work. The five block machines of face-down, hand-tamp type are ranged in a row on the other side of the room. For the transport of the units 66 cars are provided and each of these is capable of carrying 52 ordinary blocks on the four decks. The pattern room is placed in a convenient position to suit the office and the bankers, and it is equipped with a band saw in addition to benches and other tools.

The total number of men employed in this factory is 21, in addition to the manager, and in 53 working days the plant turned out 33,018 concrete blocks and 3,861 pieces of special trim stone, besides 460 small fence posts and two water-tanks. It has been found that one block man, when working uninterrupted, is able to turn out from 300 to 350 plain blocks a day or 200 special-faced blocks. A moulder and one helper turn out from 30 cu. ft. to 50 cu. ft. of dimension stone a day, the quantity varying, of course, with the facing requirements. The bankers on which the dimension stone is made are 25 in. above the floor on which the moulder stands, and they are made of 2 in. by 12 in. wood rails supported by posts. The convenience of the worker, and therefore the amount of work to be done, depends, it has been found, upon the height of these bankers.

The general lay-out and equipment will, of course, be influenced by many factors, such as the output required, the area of the site available, the nature of the work to be done--whether chiefly block work or special moulded units—and similar matters, but the example here given will indicate broadly some of the chief points to be considered in the arrangement of the plant generally.

Curing.—After water has been added to Portland cement and aggregate the manipulation of the mixture and the subsequent handling and protection of the product should be with due regard for three considerations :—

(1) The time of the initial set of Portland cement places a limit upon the manipulation of the mixture.

(2) The conditions for curing must be such that the product will not be rapidly dried.

(3) Temperature influences the hardening of concrete. Heat quickens it, cold retards it, and freezing interrupts the hardening process for the period in which this low temperature continues.

The time in which all manipulation of the concrete must be completed will vary somewhat with the cement, and can be taken as between twenty minutes and one hour. In most cases concrete should be handled within thirty minutes from the time it is mixed, and the moulded product, at rest and undisturbed, should be left to cure in a moist, warm atmosphere, sheltered from the sun and protected from draughts.

Wet Process.—In wet process casting, where sand moulds or a large number of special wood, plaster or glue moulds are used, a large casting area should be used free from direct sunlight, and the products should remain where they are cast until they can be removed from the moulds for surface finishing. The smaller products are ordinarily surface-treated by rubbing, brushing or tooling in from 24 hours to 48 hours after casting and the units are then carefully piled indoors to remain for at least one week.

Tamped and Pressed Products.—In curing machine-made products it is, of course, necessary that the units be taken away as moulded, but with the use of pallets this causes no difficulty. If labour is cheap and rack space is very large natural curing will be satisfactory, but when the output is considerable the natural line of development is in the adoption of steam curing. With steam curing the products may safely be removed to the yard in 48 hours, when the weather is warm, or in 72 hours in cold weather, as the strength attained in this time is greater than that possible with natural curing and sprinkling in the seven to ten days in which the products must be sheltered.

(*To be concluded.*)

REINFORCED CONCRETE ACCIDENTS IN GERMANY FROM 1911 TO 1918.

By Dr. W. PETRY, Obercassel.

The following is a translation from the first part of an article which appeared in Beton u. Eisen from the pen of Dr. W. Petry of Obercassel. In reproducing this account of accidents to structures of reinforced concrete we think a useful cause will be served as the investigations here dealt with plainly show that it is not the material which is at fault, but rather that the failures are due to other causes, as a perusal of the subjoined article shows. As stated below, the accounts of such accidents to reinforced concrete structures are frequently exaggerated or inaccurate, and it is not legitimate to infer the untrustworthiness of this form of construction from the occurrence of accidents. But on the acceptance of the fact that it is by our failures we learn rather than by our successes, we publish this report, hoping it may be of use and interest to our many readers.—ED.

A STATISTICAL record of all accidents to reinforced concrete structures was established by a decree of the Prussian Minister of Public Works dated 18th September, 1911. All the more important cases are reported on by an expert. Down to the end of 1918, 22 such reports have been published, namely, 1 in 1912, 3 in 1913, 8 in 1914, 2 in 1915, none in 1916, 2 in 1917, and 6 in 1918. The present article deals with the results of these investigations, omitting all details which do not bear on the cause of the accident. Thus, whether loss of life or injuries are caused, or grave material damage produced, whilst of great public importance, is without significance for technical purposes.

The accounts of such accidents in technical periodicals are frequently exaggerated or inaccurate. It is not legitimate to infer the untrustworthiness of this mode of construction from the occurrence of accidents, and the extensive development of concrete and reinforced concrete construction shows that it is much more than an imperfect substitute for other modes of construction, as it has been recently termed by a technical journal on the ground of some American experiences.

It is readily comprehensible that accidents with concrete and reinforced concrete structures should at first be more frequent than with other materials which have been longer in use. A period of infantile diseases has to be passed through, and although we can now declare that reinforced concrete construction has passed its infancy, it must not be forgotten that, whilst it offers no greater constructive risks than the older methods of construction yet, more than in any other case, the most careful execution is necessary, calling for experience on the part of the workers, from the workmen themselves to the directing engineer. This detailed and impartial record is therefore very welcome.

ACCIDENTS TO STRUCTURES OTHER THAN TRUE REINFORCED CONCRETE.

The 22 accidents on which reports have been made include four in which special methods of construction, other than the usual cement and aggregate with round steel reinforcement, were employed. It is not proposed to discuss how far the special construction may have been responsible for the accident. In the following cases the statical computation was defective, combined in 1 and 2 with weak construction, and in 3 with imperfect execution.

CASE 1.—*Collapse of a Gable Wall.*—Three windows were separated by brickwork piers, constructed of tuffstone, only the four upper courses being of brick. Over the windows lay three reinforced concrete beams of a special system, probably considered as a continuous beam. The floor of the second storey was of similar beams placed side by side, and subjected to much bending. When the roof was set in place, cracks were seen in the piers. The architect instructed a mason to repair a pier and to support the beams over the windows if any considerable replacement of stone became necessary. This was not done, but the mason removed the loose courses, when more stone fell out than was expected, and the pier collapsed, and with it the whole front of the house above the ground floor. The side walls remained standing, but one of them was much bent outwards. Computing the beams as a continuous one, the load at the time of the accident is found to be 67 kg/cm^2. compressive stress in the concrete, and 2,150 kg/cm^2. tensile stress in the steel. Under the full working load these stresses would have become 93 and 2,990 kg/cm^2. respectively. The beams were, therefore, certainly too weak, but this alone would not have brought about the collapse. The gable wall probably behaved as an arch and relieved the beams. It was a mistake to use tuffstone. The piers were eccentrically loaded, so that the actual stresses in them and in the beams were greater than was computed. When stones fell out during the repair of a pier, this pier failed to give support, the beams could no longer carry their load, and the whole collapsed.

CASE 2.—*Collapse of a Reinforced Block Floor.*—This floor had a span of 7·40 m., being built in at one end and freely supported at the other. After removing temporary supports, which had remained for 20 weeks after construction, the floor being exposed to heavy rain, a section of the floor, 5 m. wide, collapsed. It was still quite moist. A similar section tested under double the working load proved satisfactory. The expert reported that the thickness of the floor was only 28 cm., instead of 30·5 cm., as intended. No computation of shearing and adhesion stresses had been made, and the hollow blocks had not been replaced, as they should have been, by solid blocks at the fixed end. The dead weight gave stresses of $\sigma_b = 98$ kg/cm^2. and $\sigma_e = 1{,}870$ kg/cm^2; and for full load $\sigma_b = 211{\cdot}7$ and $\sigma_e = 4{,}040$ kg/cm^2. This floor should therefore never have been sanctioned. The execution, apart from the diminished thickness, was satisfactory, the gravel being good and the mixture 1 : 4. The cement is reported to have contained too much carbonate and sulphate. The concrete of the collapsed portion crumbled between the fingers, and had broken away from the steel and from the blocks. The computation and execution had been left entirely to the contracting firm.

CASE 3.—*Collapse of a Hollow Block Floor.*—This accident is attributed by the expert to bad execution and faulty computation. The direction was in the hands of an architect, the construction of the reinforced concrete in those of a master mason, and the computation of the hollow block floor was performed by a reinforced concrete firm, the official permit stating that "The work is authorised, subject to the static computation of the reinforced concrete construction." The architect, whose previous experience of such work was inadequate, left this to the master mason, and, when the latter had no misgivings, pushed on the execution of the work. The computation was erroneous and gave too small a section. The concrete was sometimes wet and sometimes dry mixed, the sand was earthy, and the floor was exposed to heavy rain for 8 days. When the floor collapsed on removal of the centering, the successive layers separated completely from one another.

Case 4.—*Collapse of a Hollow Block Floor.*—In this case the cause was insufficient centering and bad execution. The hollow blocks take the place of centering, resting during the concreting on wooden strips supported by flat iron bars on edge wedged into place. These bars remain, and form the reinforcement of the concrete ribs. According to regulations, the wooden boards should be supported at the ends and also every 2 metres by beams, and during concreting they should be kept in the correct position by oblique boards nailed underneath. This was not properly done in the present case, or the accident would not have happened. The expert found the supports insufficient, the beams at the ends having been most likely omitted, so that the thrust was taken during the hardening of the concrete only by the flat iron bars extending into the side walls. A computation gave excessive pressures of the iron on the walls, pressures which must have been increased by the great bending of the floor. Examination of fragments showed that the concrete surrounding the iron was of loose texture, and not adherent to the iron. It was also found that the ribs were first concreted, and the upper concrete plate only later, and the latter had not adhered either to the ribs or to the blocks, so that the resistance to shear was very small. The span of the floor was 5·16 metres. The other spans, of the same dimensions, were subsequently tested under load, and all but one resisted successfully. This one broke away, and its flat iron bars all buckled.

These four cases of special constructions show that the failure is usually due to more than one cause. The contractors and computers are partly responsible but in cases 2 and 3 some blame rests on the architects or building authorities.

In the remaining cases, the first five (5 *to* 9) *are due, not to the reinforced concrete construction, but to other causes.*

Case 5.—*Collapse of Centering.*—The expert reported that the statical computations were correct, but that vertical loading of the centering had been assumed. When placing the shuttering for the floor, however, a horizontal thrust was unavoidable, and this was the cause of the collapse. As the building was required in haste, the originally planned lateral strengthening of the centering was not erected. The legal action which was taken was not proceeded with, as personal responsibility could not be proved.

Case 6.—*Collapse of a Concrete Floor.*—The investigation showed that the section which collapsed, 35 m². in area, was only supported by 5 props, 10 by 10 or 12 by 12 cm. All the props were in 2 or 3 sections, joined up with old boards, some of which had burst. *The accident was therefore not due to the concrete floor, but to the insufficient centering.*

Case 7.—*Collapse of Centering.*—The experts who examined the structure after the collapse could not at first recognise the cause, the whole being a heap of rubbish, but it was clear that the centering had given way. The wood was not defective, and an adjoining section was in good condition, although constructed in the same manner. On account of the great height of the storey, the centering was arranged in two stages, separated by horizontal beams. The vertical struts were round, one row standing under each panel of the floor, and two under each beam. The struts rested below on packing pieces and wooden wedges. The longitudinal stiffening was of planks nailed to the beams before mentioned, and partly continued as far as the side walls to prevent lateral movement. This is a usual type of centering. There had been heavy rain for several days before the accident, and the wedges under the struts had probably swollen and caused buckling of the struts. This was favoured by the rather weak longitudinal stiffening. The buckling of one row of supports under a floor panel, causing movement sideways, must have caused the destruction of the other struts. The expert decided that there had been laxity of control, and no proceedings were taken.

CASE 8.—*Collapse of a Floor.*—It was shown that the entire floor had fallen, almost in one piece. The construction and the concrete were unexceptionable, and the fault lay in the supporting walls. The lime mortar was quite soft, and the stones were easily separated, without any adhering mortar.

CASE 9.—*Collapse of a Reinforced Concrete Floor.*—Three superimposed reinforced concrete floors were placed in an existing building for warehouse purposes. There was a girder in the middle axis, supported on reinforced concrete columns and built into the gable walls at the ends. The end support gave way, causing the girder to collapse for a length of 5·48 metres, carrying the six neighbouring floor panels with it. At the time of the accident the load was only 600 kg/m^2., whilst the floor was calculated for 1,000 kg/m^2. The investigation showed that the concrete was generally good, but that the reinforcement had not been carefully laid, and the supports of the secondary joists were imperfectly concreted. At the support of the main girder in the outer wall the steel did not extend far enough into the wall ; it should have been continued to the very end. The chief responsibility for the accident lay with the masonry of the gable wall, which was constructed with lime mortar of loose consistence. Even before the erection of the floors the wall had bulged to the extent of 30 cm., and was therefore very defective. The direction of the work was peculiar. The owner had entrusted the firm A with the construction of the floors ; this firm had appointed the firm B to supply and set the steel in place, including the making of the statical computations. The foreman C and the carpenter D, both employed by the firm A, were prosecuted. C was in charge of the construction, but was only instructed by his firm to supervise the reinforced concrete construction, whilst D had merely charge of the concreting. Neither was, in the opinion of the Court, bound to test the stability of the walls before erecting the new floors.

On considering cases 5 to 9, it will be seen that only in case 7 was the contractor or his agent free from blame. In case 8, how far the contractor was able, before preparing the floor, to test the stability of the existing wall, has not been determined, but in case 9 such an investigation was certainly possible, and although the Court held that the contractor was not compelled to make such an investigation, yet its omission implies carelessness, or at least a lack of technical conscience. In case 5 the responsibility of the contractor was not proved, but it was proved in case 6.

FAILURES OF REINFORCED CONCRETE STRUCTURES PROPER.

The remaining 18 cases refer to failures of actual reinforced concrete structures. Two may first be mentioned in which failure was due to false or imperfect computation and errors of construction, or to overloading not provided for in the computation.

CASE 10.—*Damage to a reinforced concrete retaining wall.*—The wall consisted of the wall proper, 15 cm. thick at the base and thinner at the top, and buttresses 20 cm. thick at intervals of 2·50 metres, resting on plates 18 cm. thick and 110 cm. broad. The whole wall was 122 metres long, and had side wings 10 metres long at each end, constructed like the main wall. After filling-in, one of the wings cracked at the angle and leaned over. On removing the earth, it was found that a part of the main wall was also damaged. Most of the buttresses were displaced horizontally; some had cracked away from the main wall completely, others were badly cracked at the angle. Others had held in place, but had become bent. The statical computation assumed an earth pressure solely perpendicular to the main wall, and even then approached the permissible limit of stress under the most favourable earth conditions. This caused a double error. In the first place, such retaining walls should not be computed like a building in which the maximum load which can occur is known. In the second, the possibility of lateral stresses in the buttresses was left out of consideration, since they were not laterally stiffened. Such pressures were set up, as the contractor for the earth work, who was unconnected with the building of the wall, dumped the filling earth in the cheapest way, in heaps progressing from one end. This caused the accident.

CASE 11.—*Collapse of a Warehouse Floor.*—The architect computed the floor for a maximum total load of 850 kg/m²., whilst 1,000 had been originally intended. In use, a working load of 1,000 kg/m². appears to have been assumed, the belief being that the factor of safety was then 5. According to subsequent calculations, which, however, have not been admitted without dispute, the load reached in places 2,850, and even 5,400 kg/m². The report attributes the collapse to an unfortunate coincidence of a number of technical circumstances, no one of which alone could be regarded as responsible.

In the cases 12 to 22 the failure is never due to a single cause, but always to several defects, including :—

(*a*) False or defective computation.

(*b*) Errors of construction.

(*c*) Deviations in construction from the statical computation or design.

(*d*) Faults in execution.

(*e*) Bad or defective execution (bad concrete, careless or incorrect setting of reinforcement, premature removal of centering, etc.).

(*f*) Imperfect supervision.

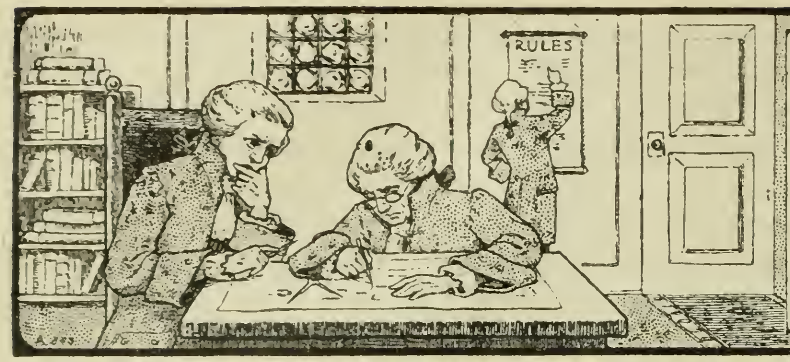
(*g*) Overloading beyond that provided for, occurring after construction.

One or more of these factors are present in each of the following cases, and have been noted for convenience under each heading.

CASE 12.—*Collapse of a Reinforced Concrete Roof.*—Causes of failure. False statical computation, errors of construction, imperfect execution and supervision.

Where the reinforcing rods crossed in the middle of the principal ten round bars should lie side by side, completely filling the breadth of the section. Actually the centering did not allow room for ten rods, so that the latter were placed, not side by side, but partly over one another, so that the distance of the rods from the lower edge, which should have been 15 mm., was in places considerably greater. In the statical computation, which was only carried out after the failure, the principals were computed, without taking into account their bent form, as if they were horizontal beams, freely supported. This gave a stress of 1,500 kg/cm^2 in the steel and 40 kg/cm^2 in the concrete. Immediately after the setting in place, the roof was covered with felt, which made inspection of the concrete impossible, and may have delayed the setting. On removing the supports, the outer walls were pressed outwards and the roof collapsed. The expert had, unfortunately, no opportunity of visiting the structure, but on the facts he held the engineer in charge responsible for several infringements of the recognised rules of construction, and for insufficient supervision. The official architect held that the reinforcement did not correspond with that assumed in the statical computation.

(*To be concluded.*)



THIRTEEN POINTS ABOUT CONCRETE

At the recent meeting of the American Railway Engineering Association, Professor A. N. Talbot, of the University of Illinois, discussed a report presented by the Committee on Masonry; and in discussing concrete he mentioned a number of points bearing on the effect of the make-up of the mixture of concrete, which we reproduce below. The points mentioned are elementary, and probably known to the vast majority of our readers, but at the present time, when concrete is about to be far more widely used, and by many builders and others who have up to the present had perhaps little experience in concrete work, it may not be amiss to reprint the following points brought out by Professor Talbot in the discussion above referred to:—

1. The cement and the mixing water may be considered together to form a paste; this paste becomes the glue which holds the particles of aggregate together.

2. The volume of the paste is approximately equal to the sum of the volume of the particles of the cement and the volume of the mixing water.

3. The strength given by this paste is dependent upon its concentration—the more dilute the paste, the lower its strength; the less dilute, the greater its strength.

4. The paste coats or covers the particles of aggregate partially or wholly and also goes to fill the voids of the aggregate partially or wholly. Full coating of the surface and complete filling of the voids are not usually obtained.

5. The coating or layer of paste over the particles forms the lubricating material which makes the mass workable; that is, makes it mobile and easily placed to fill a space compactly.

6. The requisite mobility or plasticity is obtained only when there is sufficient paste to give a thickness of film or layer of paste over the surface of the particles of aggregate, and between the particles sufficient to lubricate these particles.

7 Increase in mobility may be obtained by increasing the thickness of the layer of paste; this may be accomplished either by adding water (resulting in a weaker paste), or by adding cement up to a certain point (resulting in a stronger paste).

8. Factors contributing to the strength of concrete are, then, the amount of cement, the amount of mixing water, the amount of voids in the combination of fine and coarse aggregate, and the area of surface of the aggregate.

9. For a given kind of aggregate the strength of the concrete is largely dependent upon the strength of the cement paste used in the mix, which forms the gluing material between the particles of aggregate.

10. For the same amount of cement and same voids in the aggregate, that aggregate (or combination of fine and coarse aggregates) will give the higher strength which has the smaller total area of surface of particles, since it will require the less amount of paste to produce the requisite mobility and this amount of paste will be secured with a smaller quantity of water; this paste being less dilute, will therefore be stronger. The relative surface area of different aggregates or combination of aggregates may readily be obtained by means of a surface modulus that may be calculated from the screen analysis of the aggregate.

11. For the same amount of cement and the same surface of aggregate, that

aggregate will give the higher strength which has the less voids, since additional pore space will require a larger quantity of paste and therefore more dilute paste.

12. Any element which carries with it a dilution of the cement paste may in general be expected to weaken the concrete—smaller amounts of cement, the use of additional mixing water to secure increased mobility in the mass, increased surface of aggregate, and increased voids in the aggregate all operate to lower the strength of the product.

13. In varying the gradation of aggregate a point will be reached, however, when the advantages in the reduction of surface of particles is offset by increased difficulty in securing a mobile mass, the voids are greatly increased, the mix is not workable, and less strength is developed in the concrete. For a given aggregate and a given amount of cement, a decrease in the amount of mixing water below that necessary to produce sufficient paste to occupy most of the voids and provide the lubricating layer will give a mix deficient in mobility and lower in strength.

A certain degree of mobility is necessary in order to place concrete in the forms in a compact and solid mass, the degree varying considerably with the nature of the work, and generally it will be found necessary to sacrifice strength to secure the requisite mobility. It is readily seen, however, that the effort should be made to produce as strong a cementing layer of paste as practicable by selecting the proper mixture of aggregate and by regulating the amount of mixing water.

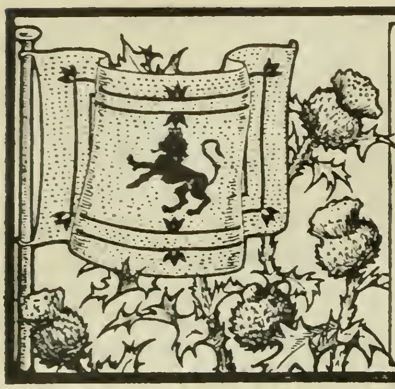
More thorough mixing not only mixes the paste and better coats the particles, but it makes the mass mobile with a smaller percentage of mixing water, and this less dilute paste results in higher strength. Any improvement in method of mixing which increases the mobility of the mass will permit the use of less dilute paste and thereby secure increased strength.

It may be added that for a small increase in the amount of mixing water the difference in the strength of the concrete after considerable time has elapsed appears to be relatively less than it is at the earlier ages, provided, of course, sufficient moisture is at hand to permit full chemical action to be maintained.

MEMORANDUM.

Concrete By-Laws.—A special committee of the Sheffield Corporation recommends modification of the building by-laws with regard to the use of concrete.

The rule relating to the composition of concrete which may be used for new buildings has hitherto read " good cement concrete composed of good broken brick or stone, clean gravel," etc. It is now proposed that the following words shall be added : " Clinker, furnace or boiler ashes, gas plant ashes, coke breeze (but not burnt ballast)." In cases where cavity walls are used, it is at present provided that the cavity shall not be less than 2½ in. wide. The new proposal is that in concrete buildings the width shall be 2 in. The thickness of each part of the wall is to be not less than 3½ in. for concrete and 4½ in. for other material. The aggregate thickness of the two parts of a concrete wall, including the cavity, shall throughout be not less than 9 in. The committee recommends that the altered by-laws shall be applied for the period of the war and for two years thereafter, and that before the expiration of such period the recommendation be further considered, and if it then appears desirable that the alterations and variations or any part thereof should become permanent, then the by-laws be revised accordingly.

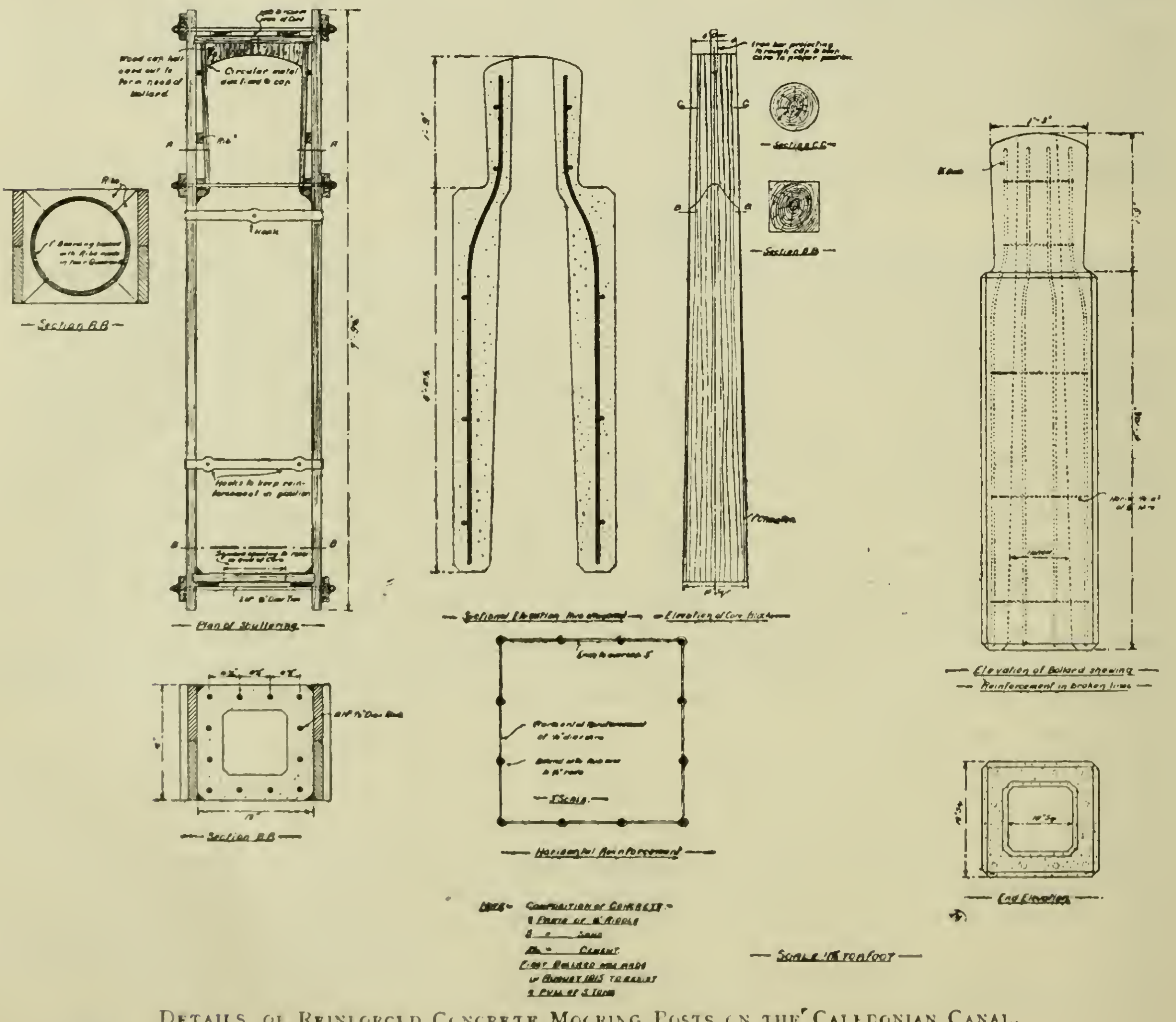


REINFORCED CONCRETE MOORING POSTS ON THE CALEDONIAN CANAL.

By EUSTACE W. PORTER, Assoc.M.Inst.C.E., etc. (Resident Engineer.)

In the following article another interesting example is given of the use of Concrete on the Caledonian Canal.—ED.

The reinforced concrete mooring posts, or bollards, shown in the accompanying illustrations, together with the mould for making them, were designed to take the place of somewhat similar posts, so commonly seen in timber, often the root end of a large tree, involving the excavation of a pit of considerable dimensions when reinstating. They have been substituted for stone posts which have failed suddenly when subjected to a heavy strain.


Wood cap hollowed out to form head of bollard
Circular metal dust lined cap
A
A
B
B
Hook
Hooks to keep reinforcement in position
Section BB
Plan of Shuttering
Sectional Elevation thro' stay
Elevation of Core Piece
Section CC
Section BB
Elevation of Bollard showing Reinforcement in broken lines
Section BB
Horizontal Reinforcement
Scale
End Elevation
Scale ½ in to a foot
Composition of Concrete
First Bollard was made in August 1915

DETAILS OF REINFORCED CONCRETE MOORING POSTS ON THE CALEDONIAN CANAL.

The concrete mooring posts are cored out, to effect a desirable saving in weight when handling, and the hollow is subsequently filled, when in place, with ballast and capped with fine concrete to exclude water.

The cost works out considerably cheaper than oak timber at present prices, and there is no question as to their durability.

In certain situations, where it is known that steel wire ropes will be used for making vessels fast, a wrought iron facing strip is incorporated with the reinforcement on the quay side, for half the circumference.

Where the ground has proved less consolidated than usual, distributing transome pieces have been laid, just below the ground surface, on the outside of the posts.

Several of these mooring posts have been in use by vessels up to 400 tons register, and have given every satisfaction.

The writer desires to express his indebtedness to the Canal Commissioners' Chief Engineer, Mr. L. John Groves, M.Inst.C.E., of Ardrishaig, for permission to publish an account of the above work.

THE FOREIGN PRESS.

Hints on Using Powdered Coal in Rotary Kilns.—(1) Use a suitable burner with air under pressure of 200 lb. to 250 lb. per sq. in. (2) Use a flame of the same diameter as the kiln and of a length up to 33 ft. (3) Avoid a coal with a high ash as this lowers the temperature of combustion and permits coal to fall unburnt and so wastes fuel. (4) Grind the coal as fine as possible; it should not leave more than 8 per cent. residue on a No. 100 sieve. (5) Regulate both primary and secondary air. (6) Prefer a bituminous coal to anthracite as it is more readily ground and burnt. (7) Dry the coal to less than 1 per cent. of moisture before grinding.—*Revue des Matériaux de Construction*, 1919, 212–215.

Wood and Reeds as a Substitute for Metal in Concrete.—In our issue of June (p. 328) we made a short reference to an article in *Beton u. Eisen* dealing with the subject of wood as a reinforcement for concrete. In a subsequent issue of the same journal further particulars are forthcoming on this subject, of which we give a short summary herewith. Experimental beams $2\frac{3}{4}$ in. wide and 4 in. high and 7 ft. 4 in. long were mounted on knife edges 6 ft. 7 in. apart. The arrangement of the reinforcement in these beams is shown in *Figs.* 1 to 7 (the measurements in these illustrations are in twenty-fifths of an inch). The reinforcing wires were fixed at the usual angle of 45°, eight wires being used.

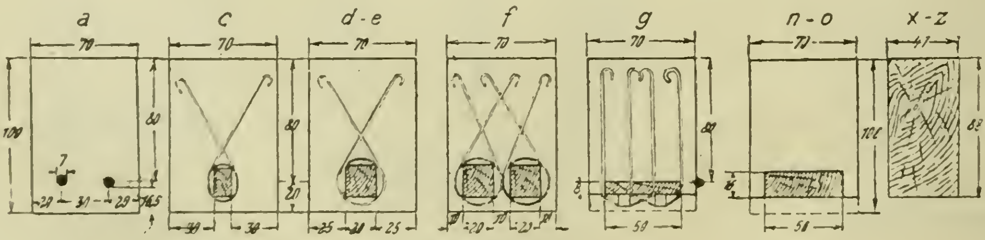
Beam *a* was the customary type of reinforcement with 1·35 per cent of steel, and was used principally to find the elasticity ratio $n = \frac{Ee}{Eb}$ of the concrete, and the corresponding ratio of wood concrete $m = \frac{Eh}{Eb}$

Beams *c*, *d*, *e*, and *f* were reinforced with wood and wire, the wooden bars being 8 ft. by $3\frac{1}{4}$ in. by $3\frac{1}{4}$ in. The breaking loads obtained with these beams showed that more wood was required as reinforcement. On doubling the amount of wood (beam *f*) the breaking load was also doubled, but owing to shearing no really satisfactory breaking load could be obtained.

Even worse results were obtained with a wooden plank (beam *g*) in which the reinforcement was 7 per cent. of the concrete and wires were fixed in position by means of wedges.

Beams *m*, *n*, and *o*, made of magnesite concrete, gave higher breaking loads.

A wooden beam of the same size as the concrete ones had a breaking load greater than beams *a* to *n*, but rather less than beam *o*.



Figs. 1 to 7.

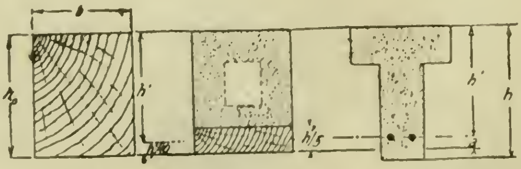


Fig. 8.

The relative strength of beams of wood (I.), wood-concrete (II.), and reinforced concrete (III.) are shown in *Fig.* 8. Hence a wooden beam may be replaced by a concrete beam containing 20 per cent. of wood and a concrete beam with only 1 per cent. of steel reinforcement. As wood is more liable to contain defects than steel, its factor of safety should be 5, whilst that of steel may be 2½.

This investigation also provides a means for overcoming some of the difficulties due to a shortage of timber, as in wood-concrete beams much less wood is employed, and in them the pieces of wood may be merely bolted or screwed together to form a reinforcing member of the requisite size, whereas in a wholly wooden beam special precautions must be taken with regard to joints.

Wood-concrete may advantageously be used instead of ferro-concrete in light structures and generally in cases where wooden beams would ordinarily be used.

Beam.	Width, cm.	Static ht., cm.	Reinforcement.	Per cent.	Weight of beam per lin. metre. Kg.	Breaking load.
a	7	8	2R.—E. 7 mm.	1·37	17·3	552·5
c	7	8	1 × 2 cm.	3·57	16·3	199·2
d	7	8	2 × 2 cm.	7·15	15·6	338·8
e	7	8	2 × 2 cm.	7·15	15·6	385·3
f	7	8	2 × 4 cm.	14·3	15·0	449·5
g	7	8	5 × 0·8 cm.	7·15	11·8	321·5
m	7	8	5 × 0·8 cm.	7·15	12·4	511·8
n	7	8	5 × 1·6 cm.	14·3	13·0	653·0
o	7	8	5 × 1·6 cm.	14·3	13·8	833·7
x	4·1	8·8	0	—	1·7	631·2
z	4·2	8·8	0	—	1·5	701·0

—D. von Empergen, *Beton u. Eisen*, 1919, pp. 85–88.

Concrete Railway Trucks.—The necessity for economy in wood and metal has led to the construction in Holland of a number of railway trucks of reinforced concrete, the frame, springs, and wheels being, as usual, of metal.—*Beton u. Eisen*, 1919.

Concrete-Wood Vessels.—According to a Norwegian patent granted in 1917 to Moe and Morch, the use of a combination of wood and concrete has the following advantages in shipbuilding : the vessel is lighter and cheaper to build, costly curved wooden planks and beams are avoided ; the outer surface of the vessel is better protected than when wood alone is used and repairs can easily be executed. In the patentee's arrangement the skeleton of the vessel is of wood, the intervening spaces being filled with mass concrete.

Reinforced Concrete Transmission Poles.—In 1917–18 a high-tension transmission-line of 40 km. length was constructed from Striesen to Dresden for 60,000 volts using reinforced-concrete poles.

The poles were constructed by a centrifugal process by Dyckerhoff and Widmann, of Dresden. Their height varied between 15 m. and 18 m. In the longer poles joints had to be made by iron rings fixed in position by screws. Photographs of the poles are reproduced.—M. Foerster, *Elektrotechnische Zeitschrift*, April 24th, 1919.

Reinforced Concrete Poles for High-Tension Transmission Lines.—The usual length of such masts ranges from 50 ft. to 60 ft. when spaced at intervals of 100 yards and calculated for a top-tension of 4 cwt. Corner poles may be subjected to a top-tension of three tons. The former are reinforced with commercial mild steel and the latter with steel having an ultimate tensile strength of 85 to 100 tons per sq. in

The masts are cast in wooden moulds containing a steel skeleton. Concrete in proportion of 1 of cement to 4 of conglomerate is then introduced in a fairly fluid condition, and the mould placed longitudinally in a machine which revolves at a high speed. All surplus water is thus expelled, and the concrete deposits round the steel skeleton in a few minutes. The pole remains twenty-four hours in the mould before undergoing a two-days' drying process in moist sand.

When completely set it is tested for elasticity and strength in a special machine. The masts have been found entirely satisfactory both from a mechanical and architectural point of view.—*Technische Blatt*, May 31st, 1919.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Elementary Principles of Reinforced Concrete Construction. By Ewart S. Andrews, B.Sc.

London: Scott, Greenwood and Son, 8 Broadway, Ludgate, E.C.4. 255 pp.+xii. Price 5/- net.

Contents.—Introductory and Historical Note—Notation—Properties of Concrete and Steel—Loads, Working Stresses, Bending Moments, and other Useful Data—Reinforced Concrete in Direct Compression—Reinforced Concrete Beams—Reinforced Concrete Beams Subjected to Bending Combined with Axial Thrust—Graphical Treatment of Reinforced Concrete Beams—Shear Stresses and Deflections for Reinforced Concrete Beams — Reinforced Concrete Columns—Some Leading Types of Reinforcement — Exercises—Appendices.

This is the second edition of a very useful treatise, written from an elementary standpoint in such a manner that the use of advanced mathematics is not necessary to enable the reader to solve the problems arising out of the matter explained. The book has been enlarged by the inclusion of the Regulations of the London County Council for Reinforced Concrete Construction. The chapter dealing with the leading types of reinforcement has also been considerably revised and brought up to date. The author explains in a clear manner the theoretical treatment of any particular problem and then proceeds to illustrate the application of the theory to a definite example, and thus the reader is able to make real progress toward the actual design of reinforced concrete. It is absolutely essential, in a treatise of this kind, to give examples in conjunction with the theory, and the author's method of arranging his text is excellent. There are also many points which can only be satisfactorily explained when the theory is being applied, and the reader who fails to study carefully the working out of the examples will not obtain full benefit from the book. The chapter devoted to the graphical treatment of reinforced concrete beams is very interesting and useful, and it is a feature which is not generally found in text-books of this nature. Another useful chapter is that dealing with combined bending and axial thrust, as this is a matter which is so frequently ignored by designers as well as students, with a result that unsatisfactory calculations and designs are put forward for members where such a condition prevails. The book is well illustrated throughout and several diagrams are given for facilitating calculations for reinforced concrete beams, which should be of particular value to students.

We can thoroughly recommend the book to students and engineers generally as a volume which contains all the essential information connected with the elementary principles of reinforced concrete work, presented in a manner which will appeal to those who require simple and straightforward explanations.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Institution of Gas Engineers.—The Institution of Gas Engineers held their annual meeting on May 29th, when Mr. A. E. Broadberry read a paper describing the application of reinforced concrete in the construction of purifiers at the Tottenham Gas Works. Our readers will doubtless recollect the illustrated article published in these pages some time ago dealing with these purifiers, to which we refer our readers for fuller details. It is interesting to note, however, that the success of the Tottenham set of purifiers has justified the adoption of the same principle to some new purifiers for cyanide extraction at the Ponders End Works. These are much simpler in construction—first, because they are much smaller, and secondly, in consequence of the difference in the process, the covers are simpler. Here, as at Tottenham, however, the covers are made of cast iron. Reinforced concrete has in this case been utilised for the supports of the runway beam for lifting the covers.

Mr. Broadberry has come to the conclusion that reinforced concrete is undoubtedly very economical, and can be made more so if standardised in multiples of even feet dimensions so as to allow of the use of standard shuttering. He urges, however, that great care must be taken in the execution of the work.

It was interesting to note from the discussion that followed that other gas engineers had been led during the war to use concrete at their gasworks, and we give the following short résumé of the discussion which followed.

Mr. W. B. Goulden (the Gaslight and Coke Co.) stated that, being compelled to put up purifiers during the war, he was driven to reinforced concrete, as steel was unprocurable, but apart from that he would have gone in for concrete, as on investigation he had found that it was cheaper than iron or steel at present prices in both cases. It had also been found admirable in use.

Mr. W. N. Booth (Woolwich Arsenal Gasworks) said he also had been forced to adopt concrete for purifiers during the war, and the results had been most satisfactory. Before treating the concrete he tested it and found the same trouble that Mr. Broadberry had, viz., leaks at the joints where work had been recommenced from day to day. To get over that, he drilled a number of small holes in the portions which showed signs of porosity and pumped in thin grout under pressure, and that solved the difficulty.

Mr. R. Bruce Anderson said that when he considered the use of reinforced concrete for purifier construction he decided only to have a concrete floor, and to use cast iron for the sides and covers. He calculated that it was cheaper in his particular case to deal with it in this way. An objection to the use of reinforced concrete for the sides was, whereas iron was usually 1 in. in thickness, the concrete was 7 in., and that reduced the inside dimension of the purifier by about 1 ft., which was a valuable consideration.

The President (*Mr. S. Glover, St. Helens*), referring to the difference in the thickness between sides made of iron and sides made of concrete, said that, although that had to be considered, there was also the point that the concrete was not corroded away to the extent that the iron was.

Mr. J. H. Brearley (*Longwood*) asked for comparative costs of the construction of purifiers in iron and in reinforced concrete.

Mr. Broadberry, replying to the discussion, said that he had never been able to detect any leakage of gas in the purifiers at the points where the work was left off in the evening and continued in the morning. There was a slight discolouration, but not the slightest trace of leakage. With regard to the question of cost, he had not mentioned this in the paper, but had reserved it for his reply to the discussion, as he was sure questions with regard to it would be asked. Since the paper had been prepared, the Tottenham Co. had decided upon a further set of purifiers for gas at Ponders End. The Ponders End purifiers referred to in the paper were for cyanide. The new gas purifiers measured 38 ft. by 20 ft. by 6 ft. deep, and the contract price for the concrete portion was £3,320. The total cost of cast-iron stanchions and steel framework and cast-iron boxes was estimated at £6,420, or just about twice the cost in reinforced concrete. These figures were at the present high prices for both iron and concrete.

Commerce Degree.—The University of London proposes to establish Degrees in Commerce, and in the preliminary letter sent out it is stated that nothing is more vital to our future commercial supremacy than the adequate training of the personnel of industry, a matter which has hitherto been left largely to chance. The proposal of the University will provide at once a standard by which such training can be measured and the staff and machinery for attaining that standard.

Provision is made both for those already engaged in offices to study for the degree in their spare time and for those who have not yet entered business to spend a period of exclusive preparation for it. Arrangements are also made for those who wish to study one or more individual subjects.

The proposals emanate in the first instance from the University, but in order to make the course thoroughly practical they have taken advice from representative committees of the several groups of trades.

Training for Workers in U.S.A.—According to the U.S. Training Service of the Labour Department, three-fourths of the industrial workers in America are handicapped by lack of proper training in their respective tasks.

The work of this Service is to increase the efficiency of this "insufficient three-fourths" rather than stimulate the output of the one-fourth already producing at a satisfactory rate, says a bulletin entitled "Some Advantages of Industrial Training," which is being distributed free by this branch of the U.S. Government.

This bulletin takes up the various questions which are of the greatest interest to worker and employer alike. Training contributes to a better spirit among employees and develops better team work with the employers, according to this bulletin.

Concrete Blocks for Houses.—At a meeting of the Yiewsley Urban District Council the following report was submitted by one of the members :—

"In accordance with your instruction I visited, in company with the Surveyor, a demonstration on concrete block making as applied to cottage building, in Caledonian Road, London, and also inspected at Totteridge a model cottage in course of erection and constructed entirely of concrete blocks and slabs. The demonstration and inspection was of an educational and instructive nature and favourably impressed us as to the utility of such methods as regards stability and economy in construction. The contracting firm claim that a considerable saving arises from this method of concrete building *v.* bricks. To prove these claims we then visited the works, and, at our request, materials were gauged and blocks turned out in a much less time than stated in the maker's booklet, which gives fifteen minutes for the initial 'set' of the made block in the mould, but in our presence a block was constructed and turned out of the mould in less than five minutes and conveyed to the drying racks, where they are left to mature for three days and then stacked ready for transporting to the job. So far, this demonstration conveyed to our minds that, in any future operations this method of construction should receive the Council's serious consideration as to the practicability of substituting this method of construction in lieu of bricks. The exteriors can be artistically finished, and the blocks lend themselves to a variety of finished surfaces and colours. In my opinion, in view of the likelihood of a large expenditure we shall have to face, it is desirable that our Surveyor should lose no opportunity in further investigating the process, particularly as to cost and comparative prices with such other methods as may come to his notice."

A New Use for Concrete—Concrete Grindstones.—It is reported that a cutlery works manufacturing knives of many varieties and sizes, which are used in many ways in timber mills, found the grinding problem a difficult one.

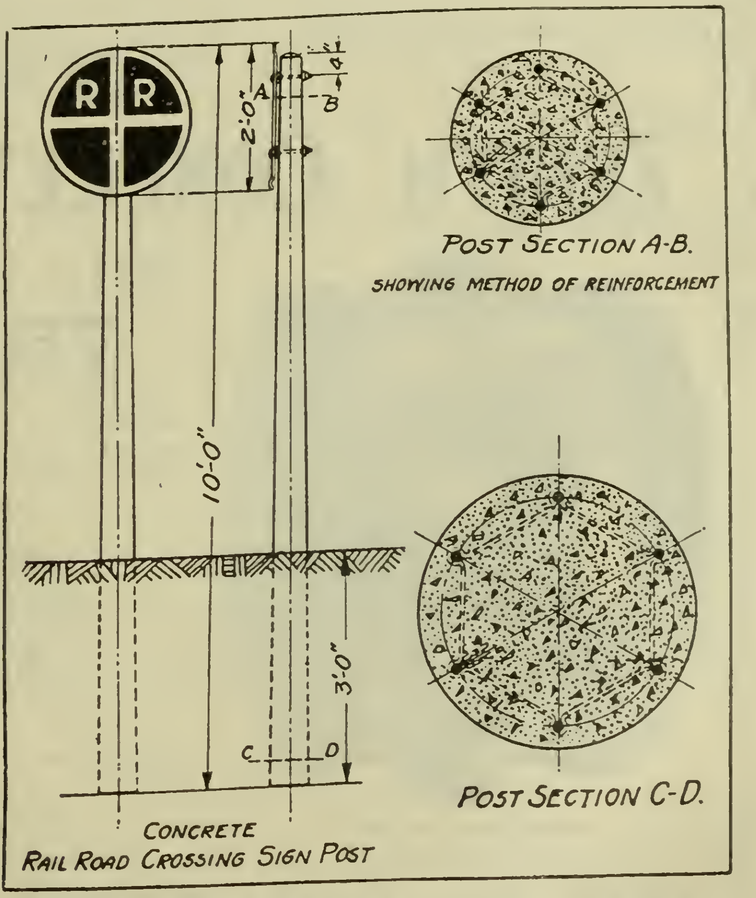
Considerable time and study was devoted to developing some method whereby the blades could be kept in condition. Finally one of the firm hit upon the possibility of using grindstones made out of concrete. Five years' experience has proved that the grindstone problems of this one works, at any rate, have been solved with concrete.

The grindstones which they used are made in two different sizes: 66 in. in diameter by 16 in. face, and 48 in. in diameter by 18 in. face. A mixture of concrete consisting of one part of cement to four parts of ground quartz is used. The quartz particles range in size from pieces about like grains of rice to fine dust.

Cement and quartz are first mixed together thoroughly in the dry state and then sufficient water is added to produce a mixture that may be readily tamped into the moulds in which the grindstones are cast. The mixing is all done by hand, because, so far, no satisfactory machine has been found to perform this service because of the quartz dust used in the concrete mixture.

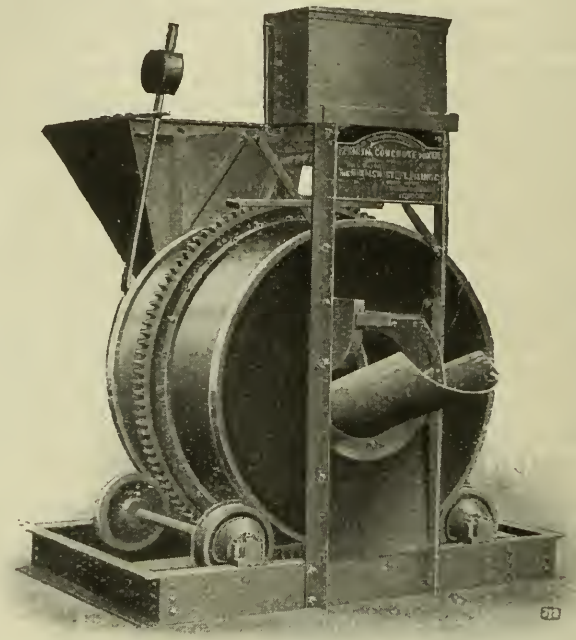
The mixed material is placed in a steel form, which is in two sections. It is tamped and left in the form for a period lasting from three to five days, during which time it is kept moist, so that the concrete will cure or harden properly and not have any soft spots in it, due to evaporation of moisture which follows lack of protection to newly made concrete. After five days the cast is taken out of the form and left exposed to the air for several months to harden thoroughly.

Concrete Posts for Railway Signs.—Our illustrations show a railway sign-post constructed of concrete by the Madison Concrete Products Co., Madison, Wis. The



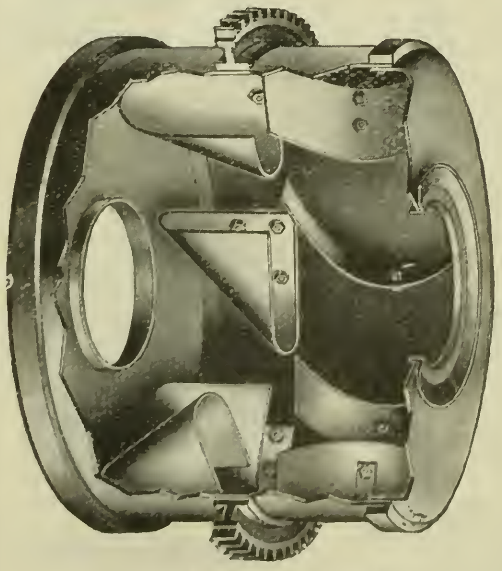
SHOVELS are CHEAP!

BUT A MAN
IS
REQUIRED
AT THE
END
AND
LABOUR
IS DEAR



The $\frac{3}{4}$ yard Standard Mixer with Fixed Hopper and Belt Drive.

"ZENITH" CONCRETE MIXERS



Internal view of Drum, showing Mixing Wings.

WILL TURN OUT FROM
75 to 300
CUBIC YARDS per 10-HOUR DAY, according to the size used.

IT WILL PAY YOU TO GET TO KNOW ALL ABOUT IT BY ASKING FOR CATALOGUES.

Write to—

THE BRITISH STEEL PILING CO.
DOCK HOUSE, BILLITER ST., LONDON, E.C.3

post is 10 ft. long, 3½ in. in diameter at the top and 5¾ in. at the bottom. The sign itself is of enamelled metal 24 in. in diameter. Our illustrations show the finished post and the constructional details.

Concrete Blocks for Cereal Mills.—Plain face concrete blocks have been used for some cereal mills at Omaha, Nebraska.

Concrete for Decorative Work.—The principal feature in the treatment of one of Chicago's small triangular parks shown in the accompanying illustration is a memorial to the American bison. The fountain itself has three of the bison heads, one at each corner, and stands upon a base which is a hexagon ; the top is circular, ornamented in an Indian sentiment. The base is moulded in a grey concrete mixture, the fountain proper is of white cement ; white, pink and black granite and silica sand aggregate with some mica for intensifying the sparkle. The total height is 15 ft. 6 in. The top diameter is 14 ft. The benches also are of concrete. The design and complete execution are by Carl Milsson, sculptor, Chicago.

Concreting Oil Wells.—By urging the concreting of oil wells in the North Cushing field of Oklahoma, in order to keep out the detrimental flow of water, experts of the Bureau of Mines Department of the Interior, U.S.A., have succeeded in increasing the production of oil from fifty wells more than 2,000 bls. a day.

It is estimated by the Federal oil and gas inspectors for Oklahoma that the total cost of excluding the water from the fifty wells was 10,000 dols., which means a return of about 165 dols. for each dollar invested.

Ministry of Pensions.—Under the provisions of the Royal Warrant, Alternative Pensions may be granted to disabled men or to the widows of men who have lost their lives in the war. Alternative Pensions are based upon the pre-war earnings of the sailor or soldier, and the Ministry of Pensions are experiencing considerable and increasing difficulty in verifying the average weekly earnings of an employee prior to the war, owing to the destruction, in many instances, of the wages books and records relating to that period. In view of increasing claims to Alternative Pension, and in the interests of widows and disabled men, the Minister of Pensions would appeal to all employers who have or have had employees serving in the Navy or Army, to preserve the records relating to their earnings during the twelve months immediately preceding the outbreak of war on August 4th, 1914.

TRADE NOTES.

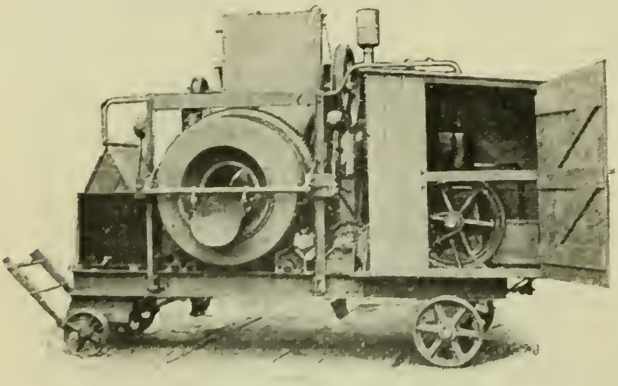
Bolt Hanger Sockets for Reinforced Concrete Buildings.—The question of fastening machinery to concrete floors and the attachment of connections for mechanical equipment in reinforced concrete buildings is of some importance, and has often given rise to difficulty, as provision is not made in the original construction for these attachments. The Building Products Company, Ltd., claim to have solved the difficulty by placing on the market their Rigifix, the use of which avoids all cutting of finished concrete. These fittings are useful in connecting to concrete work the following: Hangers for treating and plumbing pipes and sprinkler systems, supports for electric fittings, cables, conduits, etc. They can also be embedded in floor slabs, beams, columns and walls. The Rigifix fittings should be fixed to the timber falsework or centering before the concrete is poured, this being best done by means of temporary bolts let into the centering at the points where the fittings are to be set. The temporary bolts are removed when the concrete has hardened. For full details and illustrated catalogue apply to the Building Products Co., Ltd., Truscon House, South Kensington, S.W. 7.

Concrete Mixer.—The British Steel Piling Company, of Dock House, Billiter Street, E.C. 3, have just put a concrete mixer on the market, to be known as the "Zenith" mixer. An important feature in this new mixer is the size of the drum, which the makers claim is of the full rated capacity, ensuring perfect mixing and freedom from splashing and spilling. The mixer is made in four sizes, with average outputs per 10-hour day of mixed concrete of from 75 to 300 cubic yards. The machine may be seen in operation at the Greenwich works of the British Steel Piling Company at the Albion and Ravensthorpe Works, 1, Greenwich Road, S.E. 10. An illustrated description showing the mixer can be obtained upon application to the above-named company at their offices in Billiter Street.

John Birch & Co., Ltd.—Messrs. John Birch & Co., Ltd., export engineers, of London, announce that they have undertaken the overseas agency of William Beardmore & Co., Ltd., the well-known Glasgow engineering firm. The Beardmore workshops are rapidly being converted from war to peace production of metals and machinery for distribution throughout the world. The Birch organisation, already far-reaching, is being further extended to meet these new requirements.

ERRATUM.

We omitted to state in our July issue that the pontoons and caissons illustrated on pp. 371-374 were designed and executed by Messrs. Christiani & Nielsen.



THE
VICTORIA
CONCRETE MIXER

shown in the illustration is fitted with our latest side loader and is driven direct by petrol engine, the plant being mounted on road wheel truck.

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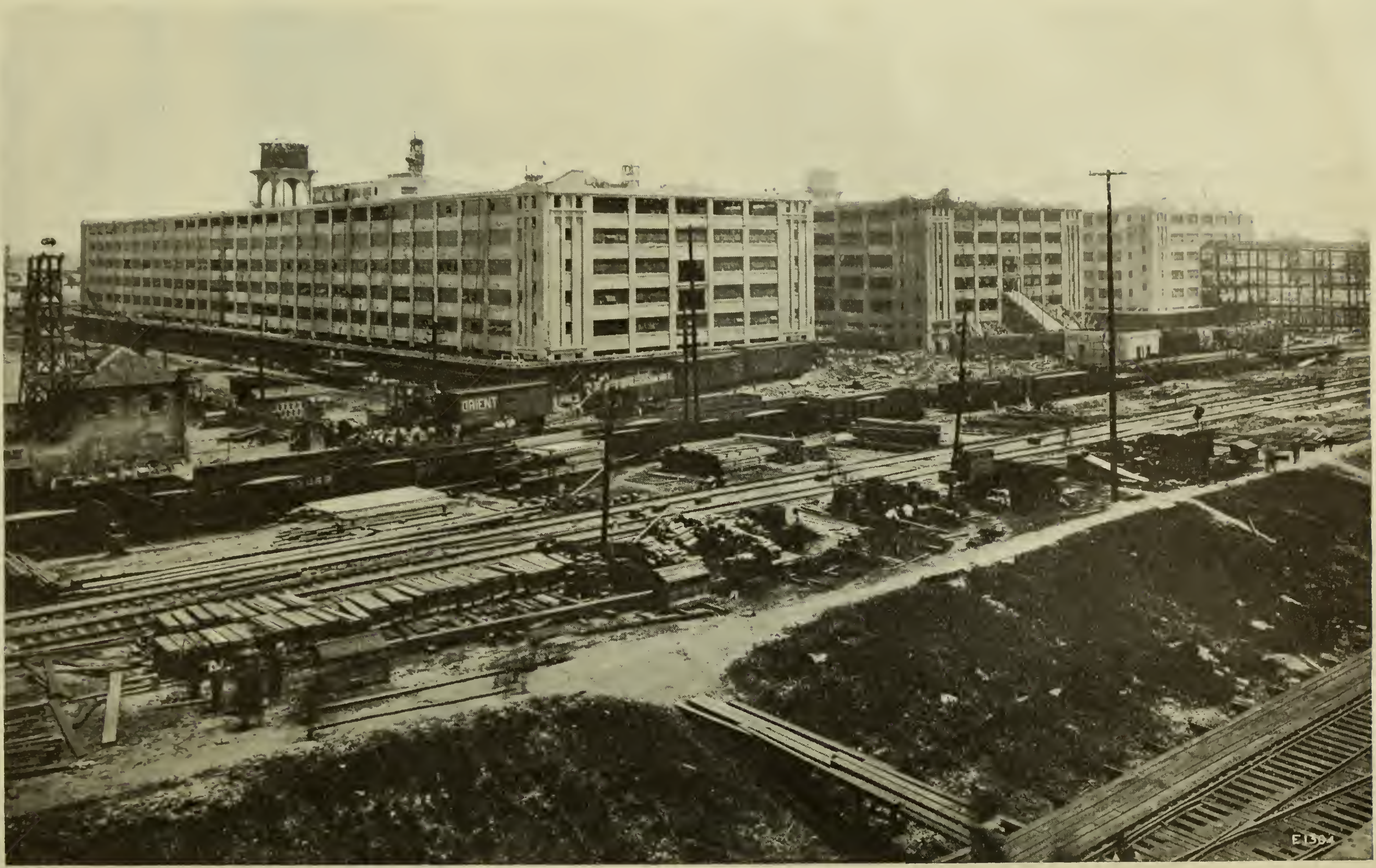


Buildings for the Army Supply Base, New Orleans.
(For description see page 483.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV., No. 9. LONDON, SEPTEMBER, 1919.

EDITORIAL NOTES.

THE MEASUREMENT OF REINFORCED CONCRETE WORK.

A VERY useful publication has been printed and issued by His Majesty's Stationery Office dealing with the method of measuring reinforced concrete work in Scotland, that being the outcome of resolutions made by the architects, surveyors, and building trades in 1914 and 1915, and the conditions contained therein came into force on May 1st last as part of the National Code for Building Works in Scotland as it was signed by authorised representatives of the three interested parties in March.

Some preliminary rules applicable to all trades are first given, and the mode of dealing with reinforced concrete work is then given in detail.

NECESSITY OF A RECOGNISED STANDARD.

A recognised standard method of measuring this class of work is very desirable, as considerable uncertainty and variation in practice have existed in the past among surveyors and builders, and it has been extremely difficult in many cases to deal with variations owing to the lack of detailed items in the surveyor's bill of quantities which are usually so complete in the other trades. Of course, a large amount of work in the past has been executed by specialist firms who prepared their own quantities and estimates, and a provisional amount covering the specialist's charges was introduced into the general contract, and the quantity surveyor has not been called upon to take off the items in the usual manner, but considerable dissatisfaction has resulted through the practice when alterations have been made and adjustments became necessary, as a basis price for each particular item had to be agreed upon. If a recognised and satisfactory mode is adopted by all parties, and a complete bill is available, whether the work is designed and executed by a specialist firm or designed by an independent engineer and executed by the general contractor, the adjustment of variations becomes a simple matter, and all parties will be satisfied.

There appears to be a growing tendency for architects and engineers to design and detail the reinforced concrete for their own schemes, and the work is then included in the general quantities, and a recognised standard method of measuring therefore becomes a necessity as well as a convenience, and it is this fact which has undoubtedly led to the publication of the pamphlet above mentioned. It seems curious that Scotland should lead the way in this respect, and we should like to see specific rules applicable to English practice also, as some of the terms used are naturally Scottish and not readily intelligible to the English surveyor and builder.

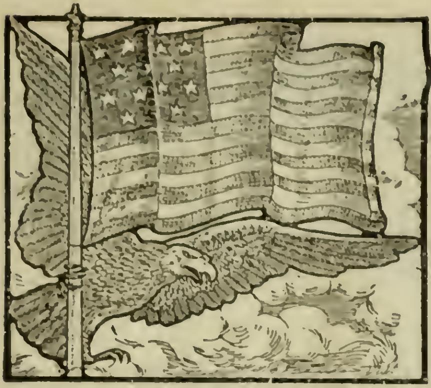
THE RULES.

The rules are divided into sections dealing with formwork, concrete and steel, and these are prefaced by some general rules which apply to boarding, sheds, temporary work, and similar matters. Under these rules the structural members of each storey of the building shall be stated separately and the schedule of quantities for each storey shall be made out in the following manner, viz. :—(1) form work, (2) concrete, (3) steel, and the height from floor to floor shall be stated immediately under the headings for each floor. It is not usual to deal with each storey separately in this manner in this country, and although it may have some advantage it does not appear absolutely necessary, because the drawings should be available for reference, and it prevents the grouping of many items by the surveyor and involves more work in abstracting and billing. Generally speaking, the mode, however, appears to have been carefully considered.

SOME SUGGESTED AMENDMENTS.

Despite this fact, however, we would put forward some suggestions for consideration in connection with any future publication dealing with concrete work. There appear to be some omissions which are more or less serious, and as an example mention may be made of circular work, such as silos or chimney stacks. Particular attention is paid to vaulted ceilings and staircases and similar types of special work, but if the surveyor is called upon to deal with a silo, or a factory chimney, these rules offer no guidance. No mention is made of roof trusses, although separate headings and details are given for the various structural members which may occur in any class of building, and this is surely an oversight. Another item that could with advantage have been included is that dealing with watertight work and the method of measurement for concrete floor cisterns and similar features which may be provided. Such work as this could not be classed with ordinary walling and flooring, and some specific rules would undoubtedly prove useful. Pre-cast concrete work is dealt with, and particular features are mentioned, but again, fence and other posts are omitted. Some of these could with advantage be measured by the linear foot, but this method would not always be applicable. When dealing with steel an item should be included for special distance pieces and additional wiring for keeping the reinforcement in position during concreting, because there are many instances where materials and labour may be called for which the contractor may fairly contend he had not provided for because no special mention was made in the quantities, although same may reasonably be required to ensure accurate and first-class work, and a provision for that could be made in a simple manner when the quantities are being prepared if the item is mentioned in the mode .and the designing engineer is called upon by the surveyor for particulars of any special work which will be required. The clause dealing with large surfaces of reinforced concrete which rest on the ground in excavation wherein it is stated that 3 in. additional thickness of concrete over the required constructional thickness shall be allowed appears to us excessive.

Generally speaking, it is, however, very satisfactory that an agreed mode of measurement for reinforced concrete work has been drawn up and published, and if the recommendations are properly applied we can safely leave improvements and revisions to follow in course of time as the result of experience gained by those responsible for the preparation of quantities for this class of work.



THE NEW ORLEANS ARMY SUPPLY BASE.

Reinforced concrete and steel have largely entered into the construction of the New Orleans Army Base, of which we give a general description below. This base is now nearing completion, and we are able to publish the following particulars and illustrations by the courtesy of Mr. Geo. H. Davis, of Messrs. Ford, Bacon and Davis, who acted as supervising engineers for the base.—ED.

GENERAL CONDITIONS.

THE New Orleans Army Supply Base is at one of the best strategic locations on the western continents, being :—

(*a*) At the terminus of the navigable water courses and railroads of the Mississippi Valley and many ship lines of both the Pacific and Atlantic oceans,

(*b*) Secluded from military attack, and

(*c*) At a location equidistant between points of origin of raw materials and the destination of manufactured products.

The base, in location, design, and construction, is completely adapted to Government and commercial service, meeting both war and peace requirements of the Army as well as the requirements of both public and private commercial businesses.

It co-ordinates all the present facilities of the Port of New Orleans, and supplies a feature previously lacking in the structures of this port.

As shown on the accompanying plans, the plant covers an area of more than 48 acres, including various structures and yards, and is composed of three reinforced concrete warehouse units of the same design, each 600 ft. long, 140 ft. wide, and six storeys in height, with a 2-storey steel and pile wharf and wharfhouse 2,000 ft. long and 140 ft. wide, with connecting bridges joining the wharfhouse with the warehouse units. The connecting bridges are of structural steel of the enclosed multiple decked type, spanning Chartres Street and the intervening railroad yards. There are approximately nine miles of single railroad track serving the plant. The yards accommodate 520 cars, the warehouse units 135 cars, and the wharf 88 cars, a total of 743 cars. The total floor space of the three warehouse units is 35 acres, and of the 2-storey wharfhouse 13 acres, a total storage area of 48 acres. It will be noted that the floor area is the same as the ground area of the site. If all of the floor area of the structures were loaded to capacity, the plant would contain more than 178,500 tons of shipping, equivalent to more than 10 days' average movement over all the wharves, private and State, in the Port of New Orleans.

The wharf is of sufficient length to accommodate at first-off anchorage five to eight ocean-going ships simultaneously, and similarly the trackage immediately adjacent to the warehouse platforms, as previously stated will conveniently accommodate more than 135 standard box cars.

COMPARATIVE COST.

The plant will cost, including the yards, the three warehouse units, the wharf and wharfhouse with complete equipment, approximately $15,000,000. As will be noted from public records, this is 1·2 times the cost of all the State and Municipal port improvements on the river front made to recent dates, including the Grain elevator plant and wharf, the cotton warehouses and wharf, the belt railroad and yards, and all the miscellaneous State-owned wharves.

COMMERCIAL ADVANTAGES.

The advantages to the City of New Orleans of this great expenditure by the Federal Government are self-evident. It goes farther toward the fixing of the centre of gravity of concentration, storage and distribution of commodities for the western hemisphere, especially South America, at this port than any previous expenditure.

The plant includes such features of design as are in use in the world's greatest ports—namely :

(*a*) Extensive storage capacity at ship side.

(*b*) Maximum loading and unloading capacity in a ship's length due to :

1. Double-deck wharfhouse.
2. Multiple storey warehouse units, and
3. Multiple deck connecting bridges between wharfhouse and warehouses.

(*c*) Loading, unloading, and transportation appliances as described.

The special commercial advantages of these features being :

1. Increased speed in freight movement, thus reducing the ship's time in port by approximately 40 per cent. over the time required at the ordinary single storey unequipped wharfhouse.

2. Reduced handling cost per ton of freight.

3. Reduced storage costs per unit of capacity.

4. Reduced insurance costs on account of compartment design and fire-resisting construction.

5. A probable further classification of harbour facilities, placing commodities such as steel and iron products, petroleum, coal, coffee, tobacco, sisal, grain, sugar, and cotton at definite locations.

ADAPTABILITY

This warehousing, handling, and shipping plant is of standard design, and completely adapted to :

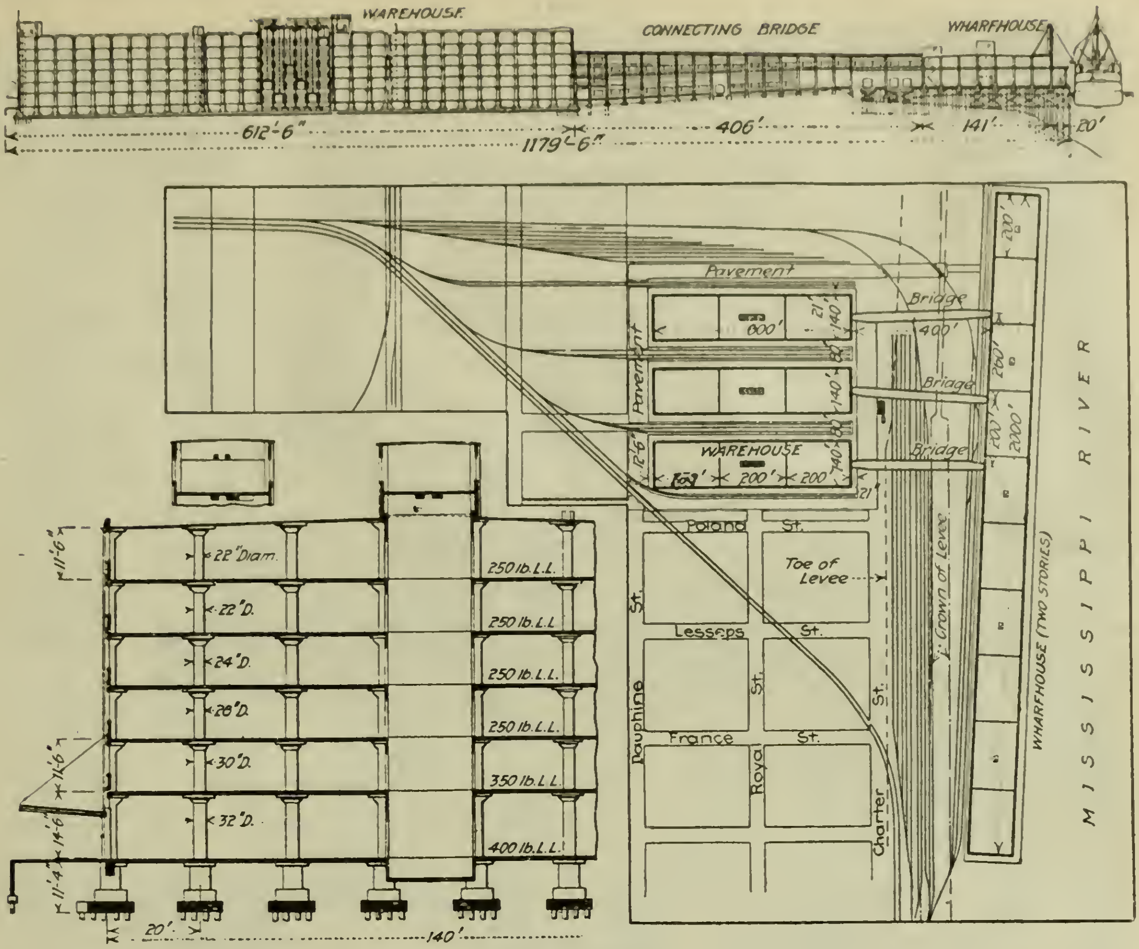
(*a*) The storage transfer and loading of miscellaneous and standard package commodities,

(*b*) Both import and export transfer and storage, and

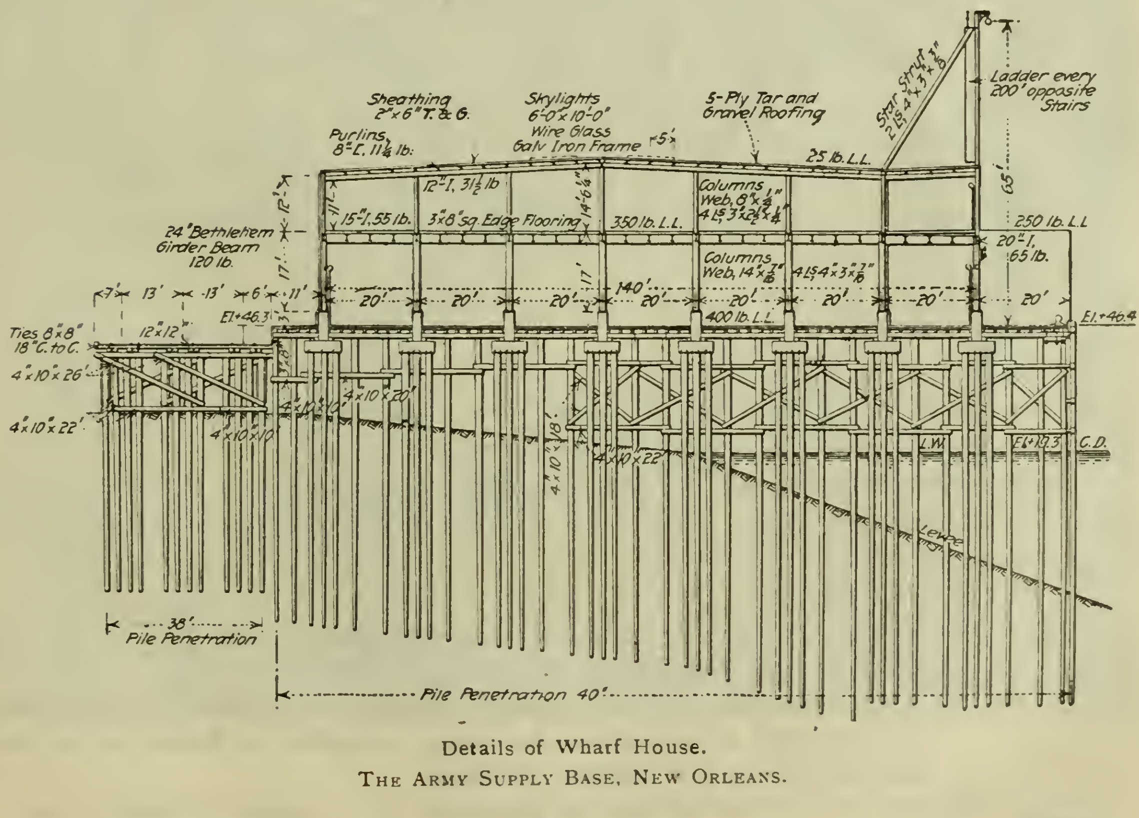
(*c*) Use as manufacturing lofts and factory machinery housing.

The warehouses and wharfhouse have a column spacing of 20 ft. centres and an external glass area of 33 per cent. and 11 per cent. respectively, being completely lighted for all the purposes noted before.

As stated, the warehouses are built for war or peace requirements of the Army as well as both public and private warehousing.



Plan and Elevations.



Details of Wharf House.

The Army Supply Base, New Orleans.

CAPACITY.

The capacity of the plant is 178,500 tons, and in standard packages of principal imports and exports its capacity is :

	Warehouses.	Wharfhouse.	Total.
Coffee (bags)	2,400,000	1,000,000	3,400,000
Sisal (bales)	350,000	150,000	500,000
Cotton (bales)	400,000	200,000	600,000
Tobacco (hogsheads) ..	100,000	50,000	150,000

FEATURES OF DESIGN.

The design of the plant and its individual units is such as to best adapt it to use in a river harbour necessitating longitudinal wharf frontage. The buildings are relatively narrow, the width being approximately one-quarter of the length. This feature allows a maximum length of railroad platforms, and an arrangement of yard and loading trackage perpendicular to the wharf. The clear storey heights of all the warehouse units is 10 ft. 8 in., except the first storey in each building, which is 13 ft. 7 in. The minimum clear storey height in the wharfhouse is 17 ft. 6 in. for the first deck, and 11 ft. for the second deck. The multiple deck structural steel bridges correspond in clear storey height with joined buildings. The loading capacity on the various floors of the warehouses units is :

	Per sq. ft.		Per sq. ft.
1st floor	400‖	5th floor	250‖
2nd floor	350‖	6th floor	250‖
3rd floor	250‖	Roof	25‖
4th floor	250‖		

The pile foundation of units ‖1 and ‖3 are designed for the total dead load and 85 per cent. of the live load, using a dead load of 12 tons per pile.

Under unit ‖2 to avoid the great difficulties and consequent delays of excavation, the standard piles in units ‖1 and ‖3 were replaced by composite piles, the lower section, approximately, 48 ft. being of untreated timber, the upper section approximately 8 ft., being of concrete installed in accordance with the design and under the supervision of the Raymond Concrete Pile Co. These piles are designed to sustain 16 tons.

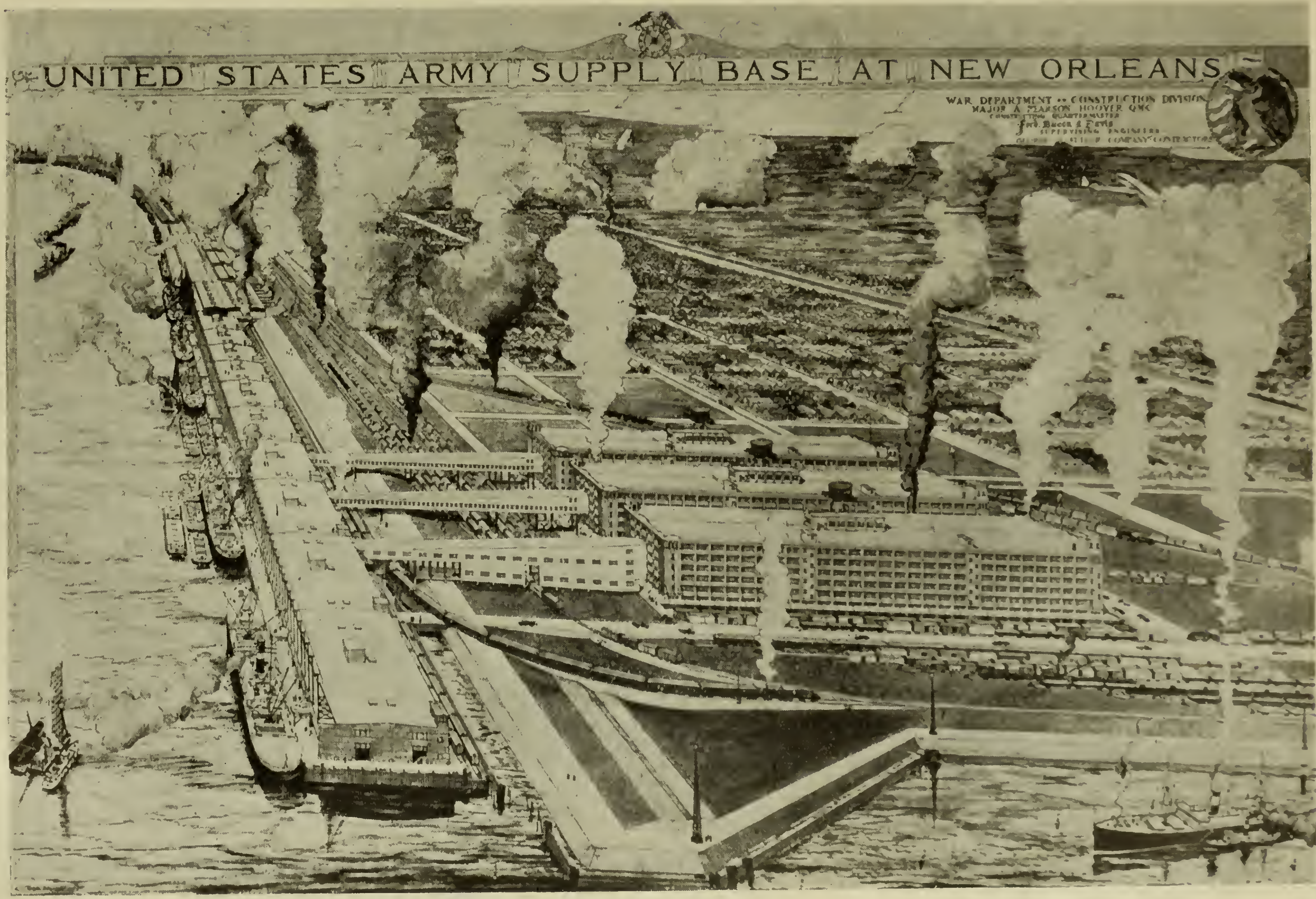
The columns are designed for full dead loads, and the following percentage of live loads :

	Per Cent.		Per Cent.
Roof	100	3rd floor	70
6th floor	85	2nd floor	65
5th floor	80	1st floor	60
4th floor	75		

The warehouse units are of reinforced concrete throughout. The structural design of the buildings is in accordance with the Chicago Building Ordinance with exceptions as follows :

A. Flat Slab Design :

1. The positive moments in bands perpendicular to the wall in the wall panels are 20 per cent. greater than for interior panels.
2. The negative reinforcement perpendicular to the walls and wall panels for the bands at columns is the same in amount as the negative reinforcement over the interior columns.
3. All negative reinforcing steel perpendicular to the walls is hooked 6 in.


UNITED STATES ARMY SUPPLY BASE AT NEW ORLEANS
WAR DEPARTMENT •• CONSTRUCTION DIVISION
MAJOR A. PEARSON HOOVER QMC
CONSTRUCTING QUARTERMASTER
Ford, Bacon & Davis
SUPERVISING ENGINEERS
COMPANY CONTRACTORS

General Perspective.
The Army Supply Base, New Orleans.

B. Beams:
  1. Continuous beams are designed for the clear span.
  2. The spandrel walls are self-supporting.
  3. Lintels supporting the flat slab floors are designed to carry the full dead and live load of one-fifth of the panel width tributary to same, considered as a uniform load.
  4. Negative reinforcing bars in end spans are hooked 6 in.

C. Spiral Columns:
  1. The Considere formula is used in computing spiral columns.
  2. The average core stress does not exceed 1,200‖ per sq. in.
  3. The concrete stress is 700‖ per sq. in for 1 : 2 : 4 concrete.
  4. The amount of spiral reinforcement is not less than ½ per cent. of the core area nor greater than 1½ per cent.
     The amount of vertical reinforcement is not less than 1 per cent. of the core area and not more than 4 per cent.

D. Laced Columns:
  1. The concrete stress is 500‖ per sq. in for 1 : 2 : 4 concrete.
  2. Lacings are not less than ¼ in. in diameter, and they are spaced not more than 12 in. centres.
  3. The amount of vertical reinforcements is not less than 1 per cent. of the effective area of the column nor greater than 4 per cent.

E. Concrete Stresses:
  1. The extreme fibre stress for concrete in slabs and beams is not greater than 700‖ per sq. in. for 1 : 2 :4 concrete.

F. Steel Stresses:
  1. Steel stress for tensile reinforcement for beams and slabs does not exceed 16,000‖ per sq. in.
  2. Steel stress for tension in beam stirrups does not exceed 12,000‖ per sq. in.

G. Temperature Reinforcement:
  The amount of temperature reinforcement is not less than ¼ of 1 per cent.

All other features of construction are in general accordance with standard specifications.

Piling is of round yellow pine, and of various lengths for various parts of the plant. Under the warehouse units the points of the piles rest in a sand stratum, at approximately –28 C.D., giving a total penetration of approximately 51 ft. The piles are driven for the entire length through Mississipi River alluvial deposit until they bring up at the sand stratum before mentioned. Under the wharfhouse all piles and all exposed timbers are treated, the treatment consisting of 16 lb. of creosote oil per cu. ft. These piles range in length from 50 ft. to 120 ft. In general piles longer than 100 ft. are spliced, the lower portion being of plain timber, and the upper of treated timber.

The cement is of standard brands, American Portland cement. The fine aggregate is obtained locally and limited in size to ¼ in. in diameter. The coarse aggregate consists of river gravel, obtained from various sources of sizes between ¼ in. and 1½ in. Concrete mix, except in special locations, is of 1 : 2 : 4 proportions.

The wharf is of treated and untreated timber, upon which is superimposed the wharfhouse of structural steel, enclosed by corrugated steel and Kinnear rolling doors.

The plant is completely equipped for fire protection, consisting of sprinkler system and auxiliary appliances, lighted by electricity, and heated by steam.

The sewage and drainage systems are in accordance with standard ordinances of the municipality.

HANDLING APPARATUS.

Provision has been made for spiral chutes for the discharge of commodities. The transfer of freight longitudinally is by means of electric tractors and trailers, and the use of hand trucks. Bridges are so designed that a minimum use of the elevator system will be required, on account of the three bridges connecting the wharfhouse and the warehouses. These bridges are multiple deck, and in total serve both decks of the wharfhouse and all the floors of the warehouses except the fifth and sixth in each of the units.

The construction of the New Orleans Army Supply Base is under the general supervision of R. C. Marshall, jun., Brigadier-General, U.S.A., Chief of the Construction Division, and in the direct charge of Lt.-Col. A. Pearson Hoover, Constructing Quartermaster.

Messrs. Ford, Bacon & Davis are supervising engineers for the work.

Road Completed.

REINFORCED CONCRETE ROADWAY IN DOCK ROAD, TILBURY.

By S. A. HILL-WILLIS,
M.Inst.C.E.I.

Member of Technical Committee National Housing and Town Planning Council; Engineer and Surveyor to the Tilbury Urban District Council.

The following is a short description of a very interesting example of the application of concrete for road work, which the author believes to be the first two-coat complete reinforced concrete roadway in this country. In a succeeding issue we hope to publish particulars of some of the interesting concrete work carried out at Tilbury.—ED.

THE South Ward of Tilbury immediately adjoining the huge dock of the Port of London Authority lies well below the river level—the surface level being only four Ordnance Datum. The soil being alluvium for a depth of 40 ft. before the ballast is reached, considerable trouble was formerly encountered when erecting buildings or constructing roadways, because of the unequal settlement of foundations.

With the advent of reinforced concrete the difficulties of providing suitable housing accommodation for transport workers and others engaged in the docks has been overcome by erecting a large number of two-storey cottages on modern town-planning lines, each pair of cottages being supported by a reinforced concrete slab raft 10 in. in thickness.

The first portion of the Council's housing scheme having been completed in 1916, providing accommodation for several hundred persons, instructions were given for extensions, and a further scheme comprising 1,054 cottages has now been approved, the execution of which is expected during the next eighteen months.

The success met with in the cottage construction by the use of reinforced concrete foundation rafts caused the Council to look to a somewhat similar form of foundation for remedying the difficulties met with in the heavily trafficked portions of their road system, instructions were therefore given their engineer to prepare specification for a trial length of concrete roadway with suitable reinforcement.

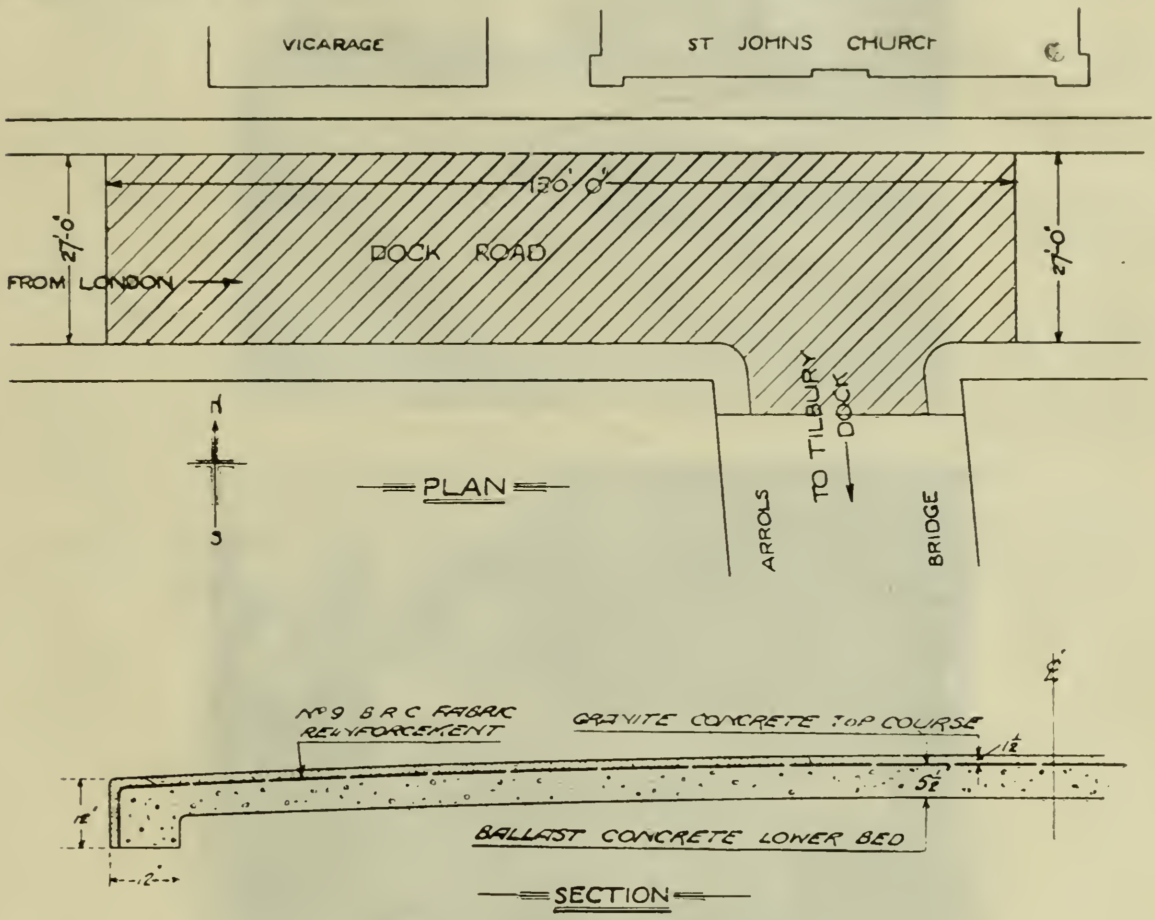
The experimental section was laid down on the main Dock Road during the months of September, October and November, and opened to traffic at Christmas, 1917. It is 130 ft. long, 27 ft. wide, and 7 in. thick.

It is level longitudinally, and has a cross-fall of 1 in 50.

It is on the main road leading from London to Tilbury Main Dock, where the Cunard, Atlantic Transport, Orient, Peninsular, and other companies' large liners are berthed, and a summary of traffic statistics shows "heavy traffic," there being more than 250 vehicles daily in addition to tractors.

Before the new roadway was laid down, the road paving had consisted of water-bound macadam resting on about 1 ft. of hard-core.

The eastern end of the roadway being the turning corner of Arrol's Bridge leading to the Port Authority's property, the heavy lorries in turning caused deep ridges to keep appearing, and much nuisance from dust in dry weather was caused to the inhabitants of adjoining property with a large accumulation of mud whenever the weather was wet.



Reinforced Concrete Roadway, Tilbury.

The existing surface of the new carriage-way was excavated an average depth of 7 in., except the portions adjoining existing kerbs, which were excavated to a depth of 12 in. as shown on section.

The finished surface thus obtained had a cross-fall of 1 in 50.

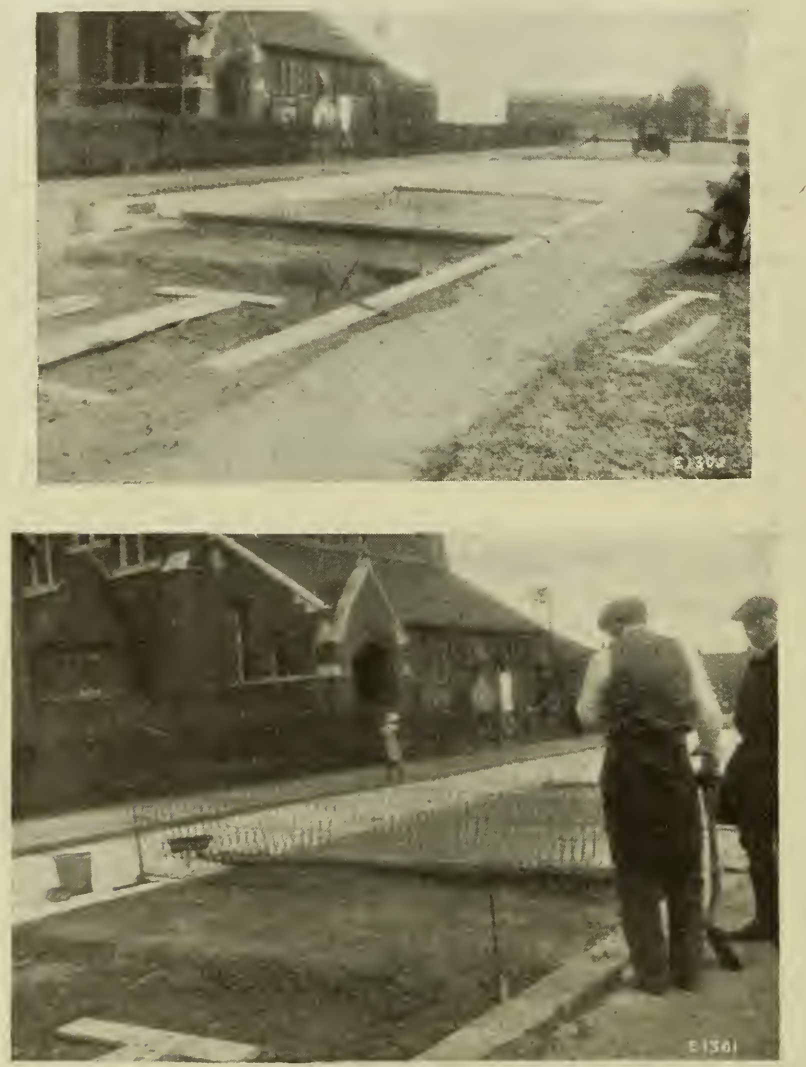
At this stage the gas and water companies' men visited the site and satisfied themselves as to the necessity for any repairs to their mains and services before the new work was commenced.

The concrete for the lower bed consisted of three parts of local ballast to the following specification :—25 per cent. of material passing through a 1-in. screen and retained on $\frac{1}{2}$ in. ; 25 per cent. of material passing through a $\frac{3}{4}$-in. screen and retained on a $\frac{3}{8}$ in. ; 25 per cent. of material passing through a $\frac{1}{4}$-in. screen and retained on a 22 screen.

One part sand all through $\frac{3}{16}$ in. screen, and one part approved Portland cement complying with B.S.S. for slow setting cement.

The top-course concrete was $1\frac{1}{2}$ in. in thickness, and consisted of one part best granite chippings graded from dust to $\frac{1}{2}$ in. One part sand all through $\frac{3}{16}$ in. screen, and one part Portland cement complying with B.S.S. for slow setting cement.

The concrete was mixed by hand to a plastic consistency, and special attention was given to the placing of the top course which throughout the entire job was carried along simultaneously with the placing of the lower bed or base.



Views showing Road in course of construction.
REINFORCED CONCRETE ROADWAY, TILBURY.

Transverse expansion joints were made in the concrete every 40 ft., and longitudinal expansion joints in the concrete alongside the kerbs. These were provided for before the concrete was laid by placing $\frac{1}{2}$ in. by 7 in. wrought boards of convenient lengths and slightly greased with a hard lubricating grease; the boards were withdrawn when the concrete had sufficiently set to allow their being removed without the arrises being destroyed, and the expansion joints were filled flush with the finished surface of the concrete with commercial soft pitch Road Board specification No. 6.

The concrete was reinforced with B.R.C. Fabric, Ref. No. 9, the reinforcement being placed upon, and pressed into the still plastic lower bed or base, the sheets being overlapped 4 in. at the sides.

The reinforcement was placed 1½ in. from the top surface of the top course concrete, and covers the whole area between the expansion joints, but in no case does it extend across expansion joints.

As the top course concrete was laid the surface was immediately struck off by means of a template resting on one kerb and one longitudinal screed, the template being moved over the surface with a combined longitudinal and transverse motion. Any excess of material accumulating in front of the template was uniformly distributed over the surface of the new road except when near the expansion joints, when the excess material was removed.

When the concrete had set sufficiently for a man to walk upon its surface without in any way disturbing it, it was kept fenced in and free from all traffic for 21 days, and the surface was kept well watered by means of a watering can for the first ten days and nights.

At each end of the new roadway a double row of 4 in. granite setts on Portland cement concrete, 6 in. in thickness, was laid to effect the junctions with adjoining surfaces.

Although owing to the increase in transport work at the docks, the roadway has had to bear a continuously increasing traffic, the road after over a year's wear is as when laid down—the repairs and maintenance have been nil—in the summer there is a complete freedom of dust—in the winter an absence of mud, and a very agreeable running surface is provided for vehicular traffic.

The cost of the complete work including granite, ballast, cement, reinforcement, and granite setts at junctions with adjoining roads was 10s. 2¾d. per sq. yd.

The contractors were Messrs. W. & C. French, Buckhurst Hill, Essex.

ROAD IN COURSE OF CONSTRUCTION.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Messrs. Andrews and Beaumont, Patent Agents, of 204-6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of June, 1919.—ED.

Reinforced Concrete Poles, etc.—*No.* 125,241. *E. O. Williams, B.Sc., A.M.I.C.E., "Shaston," Ardmore Road, Parkstone, Dorset. Dated April* 25/18.—Concrete poles, posts, columns, etc., are constructed in accordance with this invention with radial arms (1) extending from a central core, webs or diaphragms (4) being provided at intervals.

Fig 1

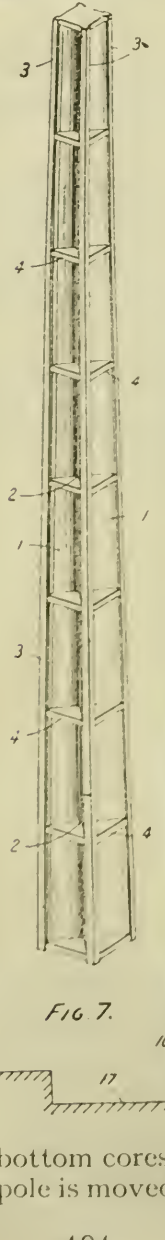


Fig. 5

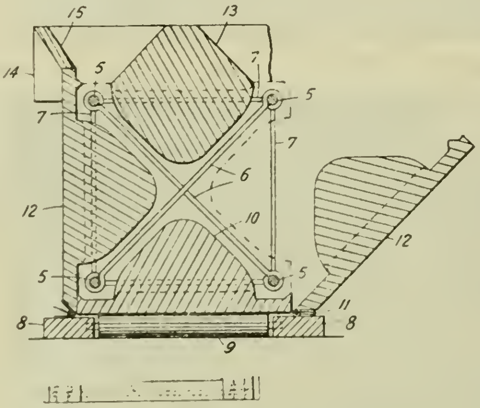


Fig. 3

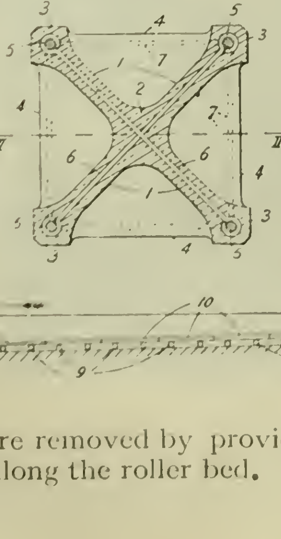
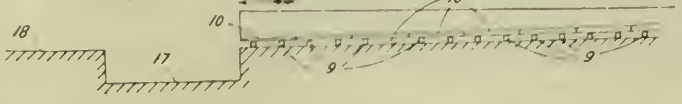


Fig. 7



The poles are preferably provided with longitudinal reinforcing rods (5) passing through thickened edges (3) of the arms, and these rods may be braced by radial transverse rods (6); additional transverse bracing (7) may be provided in each of the diaphragms (4).

With this arrangement the whole reinforcement forms a rigid unit, which can be assembled in one shop, and then taken to the casting shop.

For casting the concrete, the mould may conveniently consist of parallel longitudinal members (8), placed horizontally on the floor of the shop with rollers (9) housed in them, and arranged between them to act as a roller bed.

Bottom cores (10) rest upon these rollers, while side cores (12) are hinged to the longitudinal members (8), the mould being completed by top cores (13), which are provided with lugs (14) to engage the side cores.

In the use of the moulds, the side cores (12) are first swung outwards, and the bottom cores are then placed in position on the rollers; the reinforcing unit is then placed in the mould and supported by suitable spacing devices, the side cores being then swung back into position and the mould completed. Concrete is then poured into the mould, and, after a suitable time interval, the top cores are lifted and the side cores swung out, leaving the cast pole resting upon the bottom cored pieces (10) upon the rollers. The bottom cores are removed by providing a pit (17) *Fig.* 7, into which they drop as the pole is moved along the roller bed.

Concrete Block Buildings.—*No.* 124,566. *T. E. Hawkins, 57, Ashburton Grove, Holloway, London, N. Dated March* 26/18.—According to this invention, the upper and lower ends of the wall slabs or blocks are adapted to be interlocked with horizontal blocks, which are in turn interlocked with transverse blocks.

The vertical blocks (*a*) are provided with projecting ribs (*d*) and recesses (*e*), which may be continuous or broken. The horizontal edges of these blocks (*a*) are arranged to engage the horizontal blocks (*i*, *j*), by interlocking ribs and grooves, which engage in turn with ribs and grooves in the transverse roof or floor beams (*k*).

Various forms of interlocking joints and grouting recesses are shown in *Figs.* 2 to 5; in the last-mentioned Figure cavities (*f*) are shown.

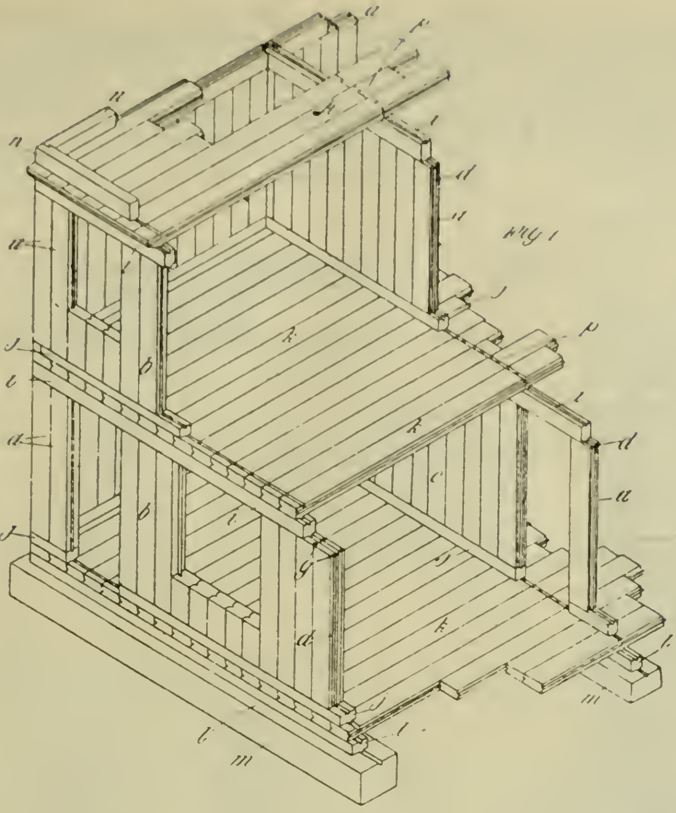


Fig 2

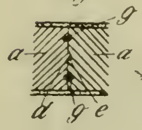


Fig 3

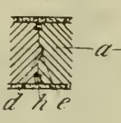


Fig 4

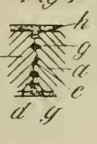
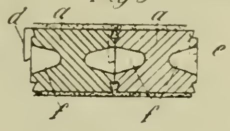


Fig 5



Hollow Reinforced Concrete Walls, etc.—*No.* 124,664. *E. Van Bavegem,* 230. *Nevells Road, Letchworth, Herts. Dated August* 16/18.—Hollow reinforced concrete walls are cast in horizontal position in accordance with this invention in the following manner :—

A thin layer of concrete is first spread upon a horizontal surface and a pre-formed reinforcing structure (*m*), with window and door frames (*h*, *l*), etc., is then inserted into the concrete and additional concrete is added to embed the projecting ribs. The spaces in the frame are then filled with sand ; a flat metal framework (*p*, *Fig.* 5), provided with the necessary door and window openings, is then placed on top and cemented in with a layer of cement or concrete. After the latter has set, the sand is removed through openings (*o*). Rings (*n*) are cast into the wall to facilitate its haulage into position.

Fig. 2.

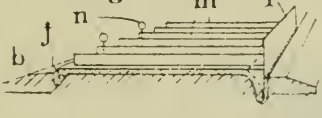
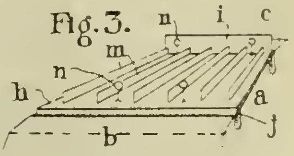


Fig. 3.



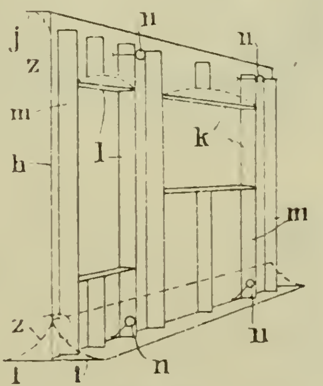


Fig. 4.

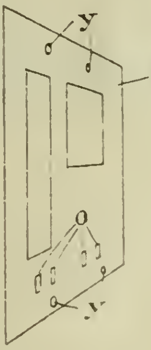


Fig. 5.

Concrete Houses.—*No.* 124,902. *F. B. Smith, Poplars, Aberavon, Glamorgan. Dated April* 9/18.—A skeleton framing for a concrete building comprises in accordance with this invention the combination of (1) base blocks (*A*) with four cut away portions to receive the bearers (*B*) for the floor slabs (*F*) ; (2) pillars (*C*) of cruciform section, fitting in the base blocks, and (3) caps (*E**) fitting upon the pillars, these caps being provided with cut away portions to receive the mitred ends of floor beams (*E*, G).

Holes or projecting lugs may be provided to facilitate lifting for erection.

No claim is made to the use, except in the combination described, of pillars with grooves to receive the ends of wall slabs or the mitring of the ends of the beams so that they can be erected at right angles to each other.

Hollow wall slabs (*D*) are shown, the spaces in which may be employed for heating or ventilating purposes.

The pillars (*C*) are shown provided with a hole into which a steel or iron rod (7*) may be placed, the space (*X*) being grouted up, but the pillars may be made of cast or wrought iron if desired.

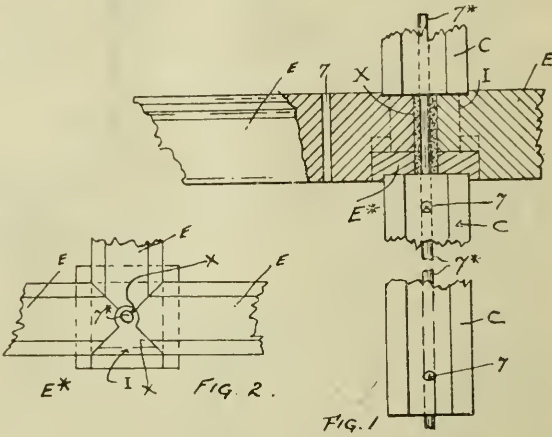


FIG. 2.

FIG. 1

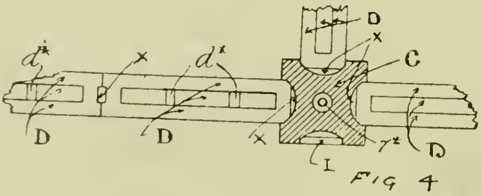


FIG 4

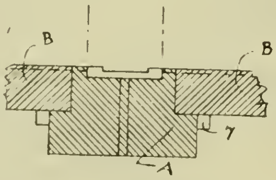


FIG 6

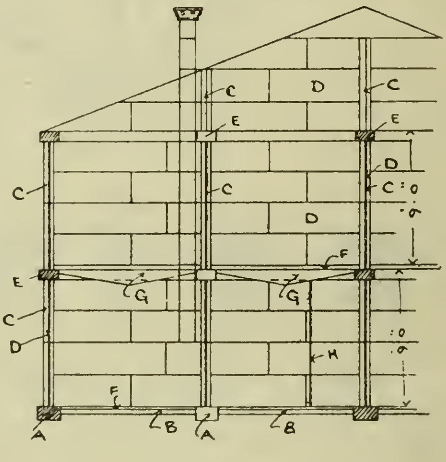


FIG. 8.

Concrete Roofing Slabs.—*No.* 125,283. *T. Furniss, 72, Ashbrow Road, Sheepridge, Huddersfield. Dated June* 20/18.—A weathertight expansion joint for roofing slabs constructed in accordance with this invention comprises a strip (*c*) of lead or other soft metal provided with channeled extensions (C^3), and a split top.

The channeled portions fit in recesses (*a*) in the adjacent slabs, and the split top portions (C^1, C^2) are bent over in the manner shown ; any moisture which may find its way under the portions (C^1, C^2) is caught in the channels.

fig.1.

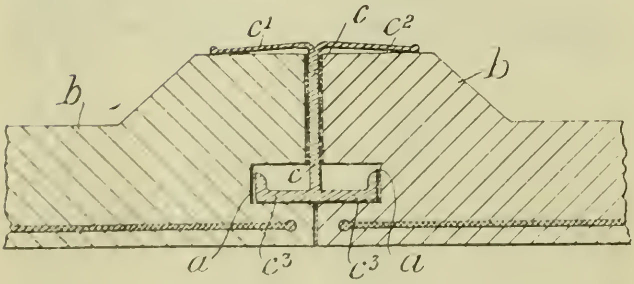
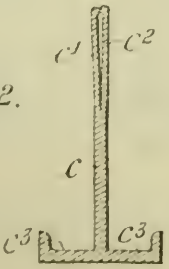


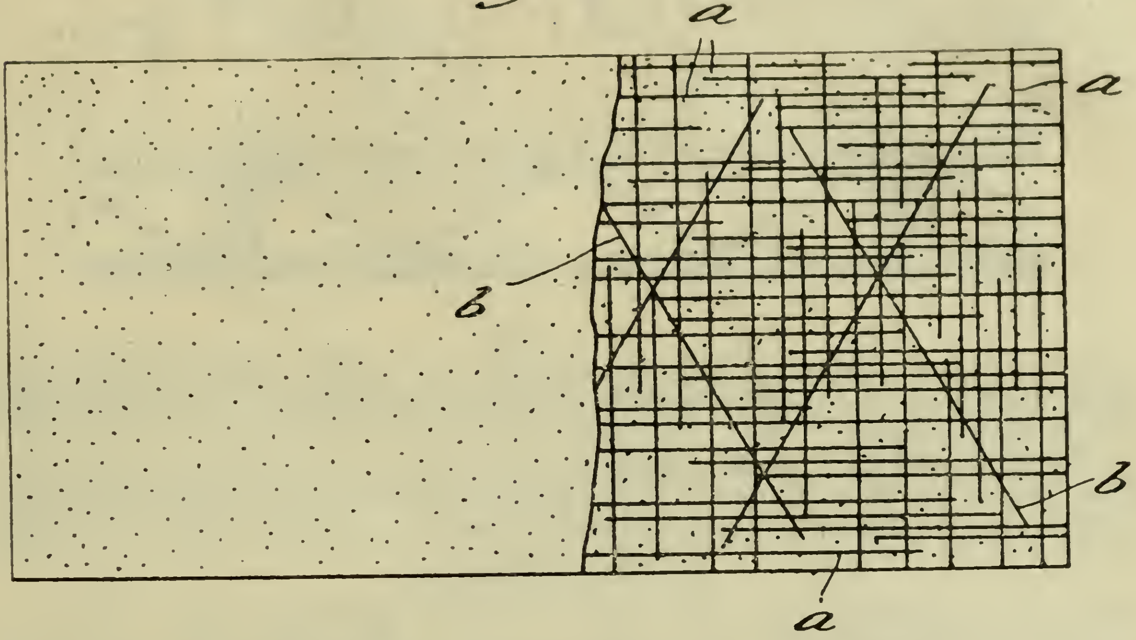
fig 2.



Building Slabs.—*No.* 124,916. *W. R. B. Palmer,* 196, *Munster Road, Fulham, London, S.W.*6. *Dated April* 18/18.—According to this invention cement or plaster building slabs are reinforced internally with split cane strips.

The strips (*a*) of cane are arranged to cross one another at appropriate distance apart, and preferably to lie both along and across the slab ; they may vary in length, and some may be placed diagonally.

Fig. 1.



The slabs may be formed upon a flat surface in a mould consisting of metal rods fitted together at the corners. After the rods have been placed in position, the bench and rod are oiled with a mixture of oil and soft soap solution applied with a rag in preference to a brush.

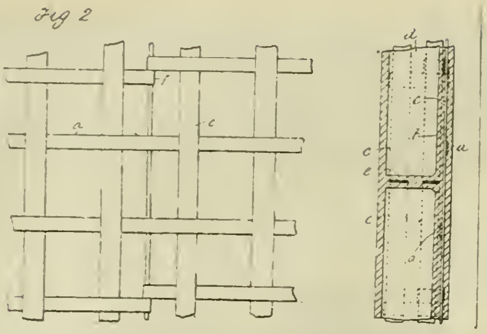
The cement or plaster is then run into the mould, and the split strips of cane are placed in it and pressed in with a plastering trowel.

If it is desired to prevent the strips from showing through on to the face of the slab, a very thin coat of plaster may first be laid inside the mould and allowed to set before the remainder is filled in.

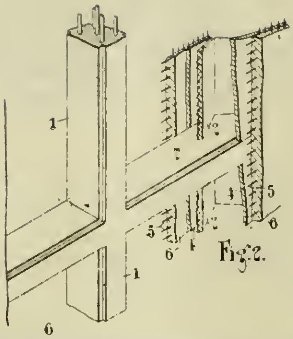
Reinforced Concrete Ships.—*No.* 125,218. *C. Hurst, Lavender Lodge, Earlswood, Surrey, and Queenborough Shipbuilding Co., Ltd., Kent. Dated April* 11/18.—According to this invention the reinforcement for concrete ships takes the form of bars (*a*) of rectangular or other flattened cross-section, so arranged that the major axes are substantially parallel to the skin of the concrete in which they are embedded. The concrete thus needs to be only very little thicker than is necessary to resist the stresses which the construction is designed to withstand. A further advantage is that the bars can be used in long continuous lengths, since, on account of their flatness, they can be readily wound on drums or made into coils to facilitate transport, and straightened when put into position in the construction.

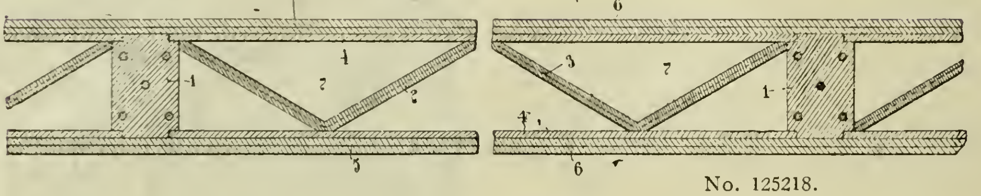
Reinforced Concrete Ships.—*No.* 125,220. *J. C. Grant, "Holly Lodge," The Terrace, Barnes, London, S.W. Dated April* 11/18.—This invention relates to reinforced concrete ships built upon the transverse frame method commonly known as the "Isherwood" system ; in accordance with the invention the transverse frames and longitudinal stiffness have reinforced panels, built-in on both sides of them to provide hollow walls without the necessity of providing shuttering.

The reinforced frames (1), usually 6 ft. to 12 ft. apart, and longitudinal stiffness (7), have reinforced slabs and fitted in on each side a sheet (2) of zig-zag or corrugated cement or concrete, which may be reinforced with netting (3), being placed between them for purposes of stiffening. Reinforcement (5) is then placed on one or both sides



No. 125220.





No. 125218.

Fig.1.

and held at requisite distance from the slabs, and by suitable spacers ; this is then covered by a layer of cement or concrete (6) which may be applied by a jet propelled by superheated steam.

Reinforcement for Concrete Ships.—*No.* 125,497 *H. Fairbrass,* 1, *Stockmore Street, Oxford. Dated April* 15/18.—According to this invention, the main reinforcing members are provided with openings adapted to take a number of wires or bars, which

Fig 1.

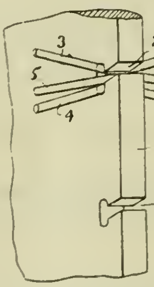


Fig 2.

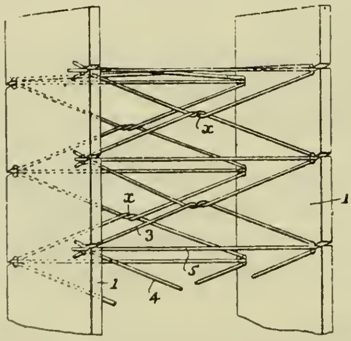


Fig 4.

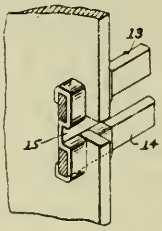
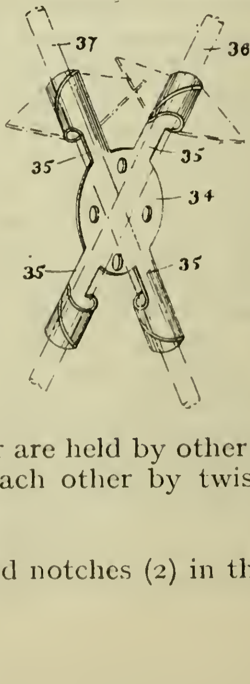


Fig. 9



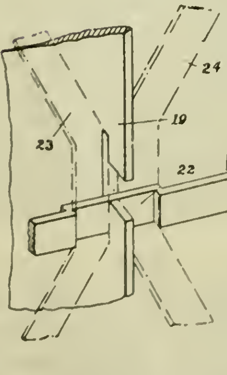
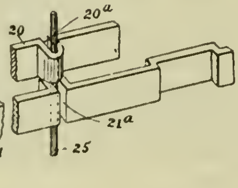


Fig.7



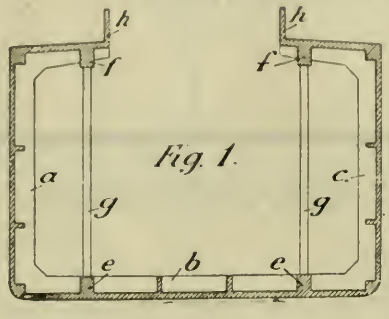
are so arranged that they hold each other in the openings or are held by other means, the wires or bars being then preferably caused to engage each other by twisting or forming joggles.

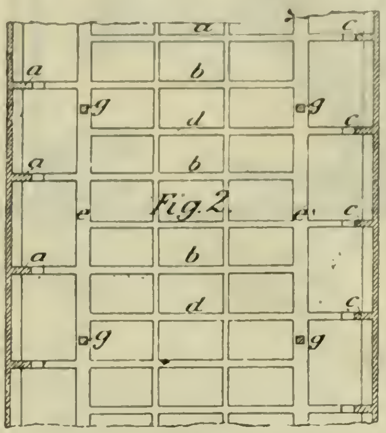
A number of alternative forms of joint are illustrated.

In (1, *Fig.* 1), the rods (3, 4) are locked in the T-shaped notches (2) in the main bars by the rod (5).

In another form (*Fig.* 4) the rods (13, 14) are locked in the T-shaped slot by means of a stirrup (15).

Fig. 7 shows an alternative to the twisting together of the secondary bars in the form of goggles (20*a*, 21*a*) into which rods (25) are fitted ; while *Fig.* 9 shows another alternative in the form of a connecting plate (34) with arms (35) which are coiled round the bars.





Reinforced Concrete Ships.—*No.* 125,248. *S. Bornstein, Thanet House,* 231-2, *Strand, London, W.C.*2. *Dated April* 29/18.—According to this invention, the cross-frames (*a*, *b*) and (*c*, *d*) of the hull of a reinforced concrete ship on opposite sides thereof are not, as usual, arranged in the same place, but are staggered as shown.

The invention is applicable to ships built entirely *in situ*, and built partly of pre-cast members.

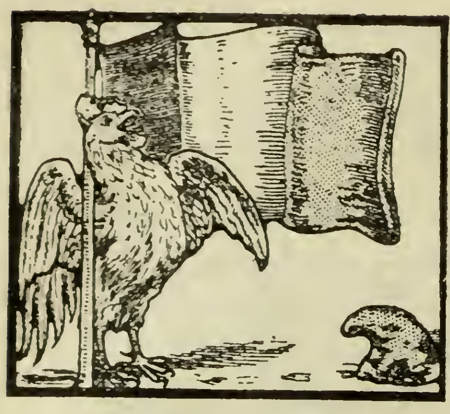
MEMORANDUM.

A New Type of Concrete Water Tank on the Panama Canal.—*The Times Engineering Supplement* reports that among the water tanks erected by the Panama Canal Executive has been one of concrete at Balboa, at the head of the railway yards of that port, in the vicinity of the round-house.

The tank has an exterior design in the castellated style. The parapet has been modelled on bulky lines, to dominate the structure and give the impression of something more interesting than a plain standpipe, which would otherwise resemble a silo.

The tank proper occupies the upper part of the structure, from approximately the top of the aperture over the door. It has a dome bottom, a segment of a sphere drawn on a radius of 14 ft. 10 in. The tank itself has an inside diameter of 22 ft., and a height of 19 ft. 6 in. from the top of the dome to the roof. The extreme height of the structure is 43 ft. 8 in. above the ground line. The outlet of the discharge pipe has been placed near the bottom of the tank, giving a head of 40 ft. above the top of the track rails. The circumferential steel is stressed to stand a pressure of 10,000 lb. to the square inch, or 62 per cent. of the stress usually allowed in the steel as used in concrete structures on the Panama isthmus.

The mixture of concrete used in this building has been designed to make the walls waterproof, the proportions employed being 1 1-3 parts of cement, 1¾ of sand, and 4 of rock. Apertures left by the removal of the bolts for holding the forms together have been filled by driving a wooden plug, about 1 in. in length, half-way through the hole and grouting it on both sides with a rich cement mixture. The foundation of the tank consists of 24 10-in. pipe piles, driven to refusal and filled with concrete. Some of the piles are as much as 50 ft. in length. The capacity of the tank is 59,500 gallons. The tank is fed through a 4 in. supply pipe off the regular 10 in. low service main, discharging near the top of the tank under the control of a float valve. The outlet for filling the locomotive tanks is through a 10 in. pipe, but at no time is there a greater demand on the mains than that through the 4 in. supply pipe. The lower part of the tank-house houses the valves on the mains. The meter for the 10 in. main has recently been removed from its previous situation, in a concrete cabin on the flat about midway between the Balboa workshops and the Administration Building, to a room within the tank-house.



CONCRETE HANGARS FOR SEAPLANES AT ALGIERS.

The following description of some reinforced concrete hangars is an abbreviated translation of an article which appeared in "Le Génie Civil," to which journal we are indebted for our illustrations.—ED.

THE Maritime Centre at Algiers, when considering the most suitable types of hangars for seaplanes engaged in patrolling the coast of Algiers, paid special attention to three types of structure :—

(i) Hangars with the lower part built of masonry and the upper part of metal.

(ii) Hangars with walls of masonry and a wooden roof.

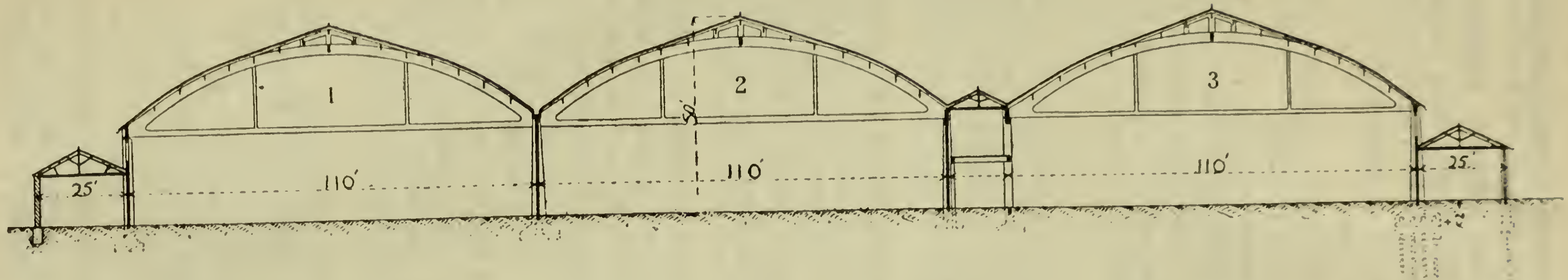
(iii) Hangars of reinforced concrete with a tiled roof.

Eventually the third type of structure was decided upon, as reinforced concrete had the advantage of making use of wholly local materials and of requiring a very small number of highly skilled labourers.

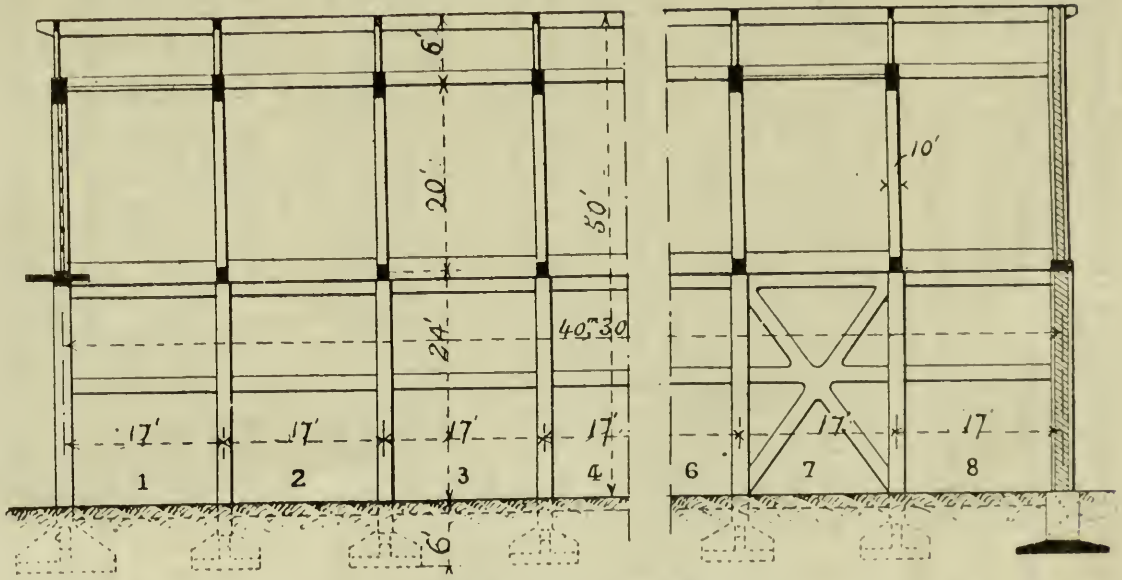
Hangars Nos. 1 and 2 have been built close to the existing temporary structures on the south of the mole at the port of Agha. The foundations, which presented no special difficulties, consisted of an old sea front covered to a depth of about 7 ft. with coarse *débris*. The bases of most of the piers or pillars are about 2 ft. below ground level, but for some piers it was necessary to go lower. The bases of these piers were made by immersing a concrete composed of 960 lb. of Portland cement to each cu. yd. of sand and gravel in the sea-water to a depth of 2 ft. below the ground level. On this the reinforced concrete could be placed in a perfectly dry state, as the level of the water in the Mediterranean does not vary by more than 16 in.

The calculation of the resistance of the feet of the piers was based on the assumption that the maximum load would not exceed 28 lb. per sq. in., including that carried by the piers and also the effect of wind pressure on the hangar. The lower portion of these two hangars consists of two rows of reinforced concrete piers at 110 ft. centres ; the space between the piers of each row being 17 ft. The tops of the piers are accurately levelled at 24 ft. above the sole in order to receive the concrete girders.

The two outer sides of the hangars and the common wall between them are built of common brickwork 6 in. thick, which are carried on two beams of reinforced concrete which rest on the piers. One of the gable ends consists of a wall of rubble masonry, the height of which varies from 24 ft. above the piers to 50 ft. in the centre of the hangars. The opposite gable consists of a reinforced concrete girder, leaving a free space 110 ft. by 24 ft. high for each hangar. The



TRANSVERSE SECTION OF THE THREE HANGARS.



PART LONGITUDINAL SECTION OF HANGAR NO. 2.

doors are 18 ft. by 24 ft., and consist of a metal skeleton covered with galvanised iron sheets. They completely enclose the space just mentioned.

The roof is constructed of a skeleton-work and end panels of reinforced concrete, the curved surface being covered with local roofing tiles with wooden laths and rafters. This form of roof has the advantage of being comparatively light, whilst effecting a considerable saving in the amount of cement and steel, which would have had to be imported, and are therefore costly.

Every 17 ft. above each pier are concrete ribs forming a principal rafter of parabolic shape and of a tie-beam to absorb the thrust of the arch.

For the running ribs the section of the principal rafter measures 10 in. by 28 in., and that of the tie-beam 6½ in. by 16 in. To avoid an excessive strain on these tie-beams two trusses connect it to the arch. The end-principals are bound together by strong concrete ties 4 in. by 16 in., placed 7 ft. apart, in line with the supporting piers and the panels. An additional tie 6 in. by 20 in. connects the tops of all the principals.

Small channels are provided above the arches so as to secure the requisite drainage of water from the upper part of the tiled roof. Lengthwise of the hangars the tiled roofing is raised above the principals ; it rejoins them near the springer, and by this means a roof is obtained which is of pleasing shape and yet drains rapidly in wet weather.

The fixing of the concrete rafters to the concrete ribs is clearly effected by nailing them on to wooden gutters, which latter are fixed directly to the ribs. Any rain-water from the two central slopes of the roof is collected in a reinforced concrete gutter 20 in. wide and 6 in. to 10 in. high internally, which is connected at each 33 ft. by stoneware downcast pipes which discharge into a main drain at ground level.

The ties in the upper part of the hangars above the metal doors are made exactly like the side ties, but there are 15 suspension trusses about 7 ft. wide between them ; half of the panels are provided with glazed frames, the others being built of a wall of brick chequerwork. These suspension trusses carry a footbridge 7 ft. wide, the outer edge of which is 3 ft. 6 in. wide, and assists in holding the guides of the metal doors, whilst its centre (2 ft. wide) forms the gangway for moving the glazed frames. In the central portion are the stays required to absorb the pressure of the parabolic girder. This gangway is also used as an outside shutter. The ends of the ribs—*i.e.*, the union of the roof principals with the tie beams—were built independently by means of a separate mould and afterwards hoisted on to the piers.

Special attention was paid to the linear changes due to the shrinkage of the concrete, to changes of temperature, and to the elastic extension of the tie-beams when under tension. With regard to the latter, the specific extension of the steel under a tension of 7½ tons per sq. in. is 0·0066 in. per linear ft. The linear expansion due to temperature is not likely to exceed 0·003 in. per linear foot. Regarding the heads of the central piers as fixed points, on the right of each outer row of piers the maximum displacement is (0·0030 + 0·0066) × 109 = 1·05 in., and this can easily occur without doing any harm as the top of the piers is convex and of large radius. Theoretically, as the girders only rest on a small part of the curved heads of the piers, there should be a considerable strain on the concrete, but this is not serious in practice, as the area of contact includes a width of 4 in., and even if the pressure reach 2,800 lb. per sq. in. it would be sustained satisfactorily by the special reinforcement of concrete by means of the superposed rows of iron stirrups, the use of a rich mortar, and the criss-cross arrangement of the bars.

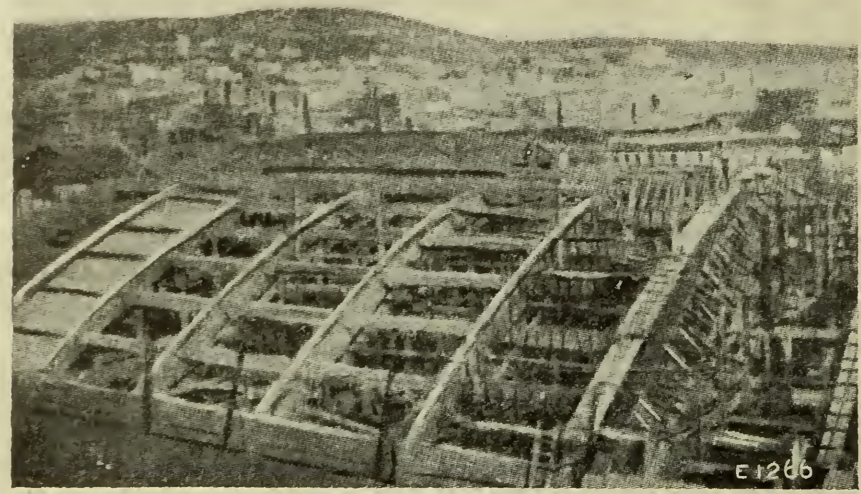
The extension due to the tension (about ¾ in.) causes sufficient flexion in the principals for this to be added to the wind pressure when calculating the allowances for the latter. The effect of the wind blowing transversely to the hangars is fully absorbed by the central rows of piers, which are most rigid and are very lightly loaded. The pressure of a wind travelling longitudinally at right angles to the end rib and the doors is borne by the gangway placed at the level of the beam of the girders. This gangway transmits the pressure to the wall ties, which reach to the top of a vertical outside shutter forming a St. Andrew's cross, connecting the two pieces of the last pier but one on the side of the gable end. These vertical shutters form fixed points for the longitudinal extensions of the hangars, and, being placed as near to the gable ends as possible, avoid any horizontal pressure which is not well within the limit of safety. The wind pressure on the upper part of the end beam is absorbed and all danger of collapse of the principals is avoided (the sides being assumed insufficient to avoid all danger). Two shutters in the form of a parabolic tie are provided, one of which is formed by the end principal with that of the neighbouring beam and the other by the principal of the last two beams near the gable end. These shutters are constructed of plain slabs, 2½ in. thick, suspended from the faces and binding the principals in their axial plane.

The doors are composed of sections or leaves covered with sheets of galvanised iron each 0·2 in. to 0·24 in. thick. Each leaf is 18 ft. wide and 23 ft. high ; there are six in each hangar. The skeleton is formed by a grating of I-bars. Two flat bars placed diagonally ensure the rigidity of the section. Each section runs on two wheels 20 in. diameter, provided with a bronze rim to lessen wear and tear at the top of the leaf. There are three bronze guide wheels 34 in. diameter with vertical axes.

The upper guides are formed of seven rows of U-bars, 2½ in. by 1¼ in., laid horizontally, with their two wings turned towards the sole : they are 6 in. apart and are bound to the outer edge of the gangway, with a space of 3½ in. between them, which allows the guide wheels a play of ¼ in.

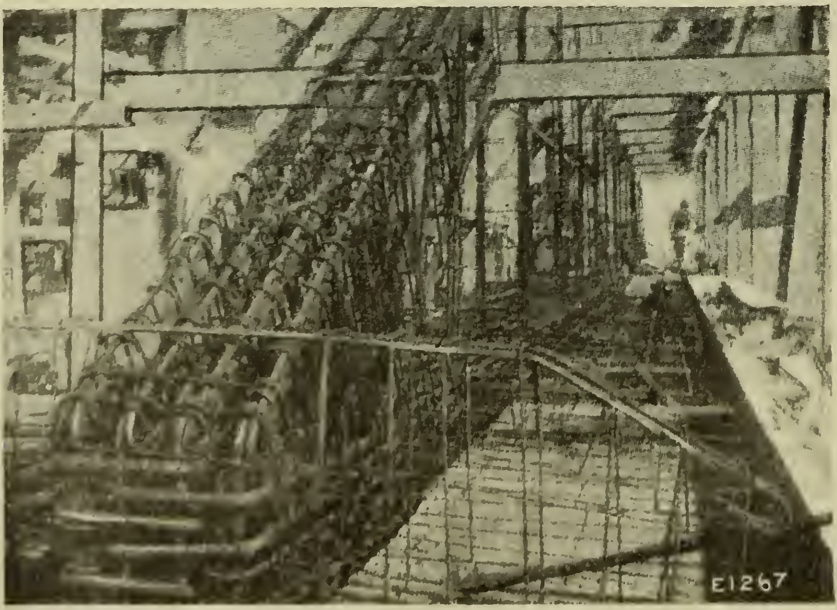
The fastenings of the U bars in the gangway have necessitated the placing of the wooden blocks in position before casting the concrete. The lower wheels, which carry the sections of the doors, run on a pair of rails weighing 17 lb. per yard, and are fastened in a bed of lightly reinforced concrete 2 ft. thick and of variable width which lies directly on the rubbish filling.

The door sections of each hangar are independent of each other ; they overlap about 4 in. without the hangars on the side walls of the shed ; the buttress stop above the floor regulates the position of all the section in each door and keeps it open. When closed, the sections are held in position by movable stops between the two rails of the runway. These stops do not project above the ground when the door is open. On the upper part of each section is fixed a stop connected to the guides so as to stop the section when the lower movable stop has not been raised. This upper stop is slowly released by the other, so that ordinarily the sections are arrested by the lower stop. The simultaneous action of all the stops in the hangar door is assured by the ties which connect them in pairs, another tie connecting the end sections to the piers ; this fastening is made on the inside of the hangar.



View of a Hangar during Construction.

The internal lighting of the hangar is effected by windows in the gable end walls, roof, and end beams. The glass used in this way, which amounts to 2,400 sq. ft. in each hangar, ensures ample lighting, even when the doors are closed.

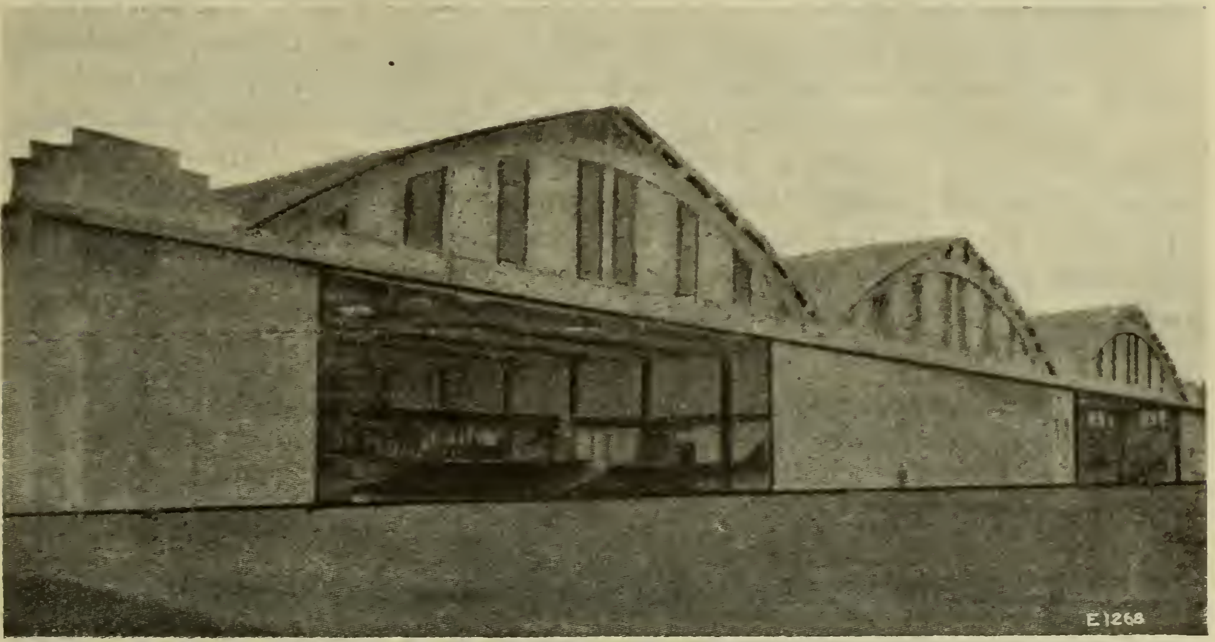


Reinforcement for Girder Ends.

A coating of cement slurry has been given to all the visible parts of the reinforced concrete so as to ensure its having a uniform appearance ; a coat of whitewash covers the visible parts of the rest of the masonry.

The removal of the centres of the concrete was commenced after the concrete had been placed. The deviation specified for the running beams was 0·12 in. to 0·16 in. to the key of the roof principals, and 0·60 in. to 1·00 in. to the level of the beams in the axis of the hangars. The maximum deflection for the girders did not exceed 0·12 in. to 0·16 in. to the level of the gangway. The displacement of the heads of the piers was not accurately measured.

The concrete was composed of 1 bag (98 lb.) of Portland cement to each 1⅓ cu. ft. of sand and 2⅔ cu. ft. of gravel, so as to withstand better the action of the moist sea air. For the same reason the chief stays were covered with at least 1½ in. concrete.



View of Completed Hangars.

A third hangar was afterwards built alongside the two others. The piers on the south side of this third hangar were erected 18 ft. from those on the northern side of the second hangar to allow room for the metal panels of the door of the latter. This intervening space is covered with a small timber roof, and midway between the piers a concrete shelf has been fixed to enable the space to be used for storing the wings of the seaplanes.

The third hangar is exactly like the other two, though built quite independently of them. The piers on the south wall act as true supports without any appreciable bending under the load imposed by the beams. The upper part of the piers is the same as that of the extreme piers of the other two hangars, but the lower part is gradually reduced to the level of the foot of the piers, the reduction being about three-fifths of the average section of the piers.

The piers on the north wall have been designed to withstand the full pressure of the wind, and are regarded as fixed points with respect to the linear variations in the structure.

Beneath the north wall is a bed of mud several yards deep and then a bed of clay. Most of the piers in this wall have been built on piles of eucalyptus, 12 in. diameter, sunk to a depth of 27 ft. to 30 ft. These piles were driven with an ordinary pile-driver, cut off at datum level, and capped with a mass of concrete 3 ft. thick. A network of steel rods 1 in. diameter embedded in this mass a little below the head of the piles ensures the strength of the latter.

The gangway which forms at the level of the end beam is extended between the second and third hangars to the right of the central shed, but is cut by an expansion joint in the line of this shed, and its ends are supported on a common pier divided into two branches at a height of 10 ft. above the ground. On the south of the first hangar and on the north of the third one the outer end of the gangway holding the door guide is extended about 23 ft. to the right of the two auxiliary buildings so as to accommodate the sections of the doors when the latter are wide open.

The ends of the gangway are supported in concrete on a brickwork extension of the walls of the auxiliary buildings (repair shops, pigeon cote, stores, etc.).

In the construction of the three hangars (excluding the auxiliary buildings) 1,230 cu. yd. of concrete and 166 tons of steel were used. Native labour was used as far as possible throughout. The second hangar was completed in February, 1918, the first hangar in May, and the third hangar in November of the same year. Since that time no cracks have been noticed notwithstanding severe variations in temperature and several wind storms.

The work was carried out under the supervision of Messrs. Auckler & Butavand, two chief engineers of the Service des Ponts et Chaussées, and of Mons. Marty of the same Service.

MEMORANDUM.

Bonding New to Old Concrete.—Small-size tests on mortar and concrete specimens in direct tension, shear and cross-bending have led W. E. Rosengarten of the United States Bureau of Public Roads to the following conclusions (reported in the official paper of the Bureau, *Public Roads*, for June 1919) regarding the practice in bonding old to new concrete :

By careful treatment new concrete can be made to adhere to old with a strength equal to 60 per cent. of monolithic concrete. If a greater bond than this is desired it will be necessary to resort to dowels drilled into the old concrete.

If no special treatment is given the old concrete other than cleaning off foreign substances before adding the fresh concrete, a bond of but 20 per cent. of the monolithic concrete is developed.

The surface of the old concrete can be roughened or treated with a 1 : 10 dilute solution of hydrochloric acid which will increase the bond by 20 per cent. of the strength of the monolithic concrete.

A bonding medium of a thin layer of neat cement butter spread over the surface of the old concrete will increase the bond 20 per cent. the strength of the monolithic concrete.

Tamping the fresh concrete hard against the old concrete, forcing the cement into the pores, increases the bond 5 per cent. of the strength of the monolithic concrete.

The above conclusions refer to a rich concrete—namely, 1 : ⅔ : 1⅓—and for leaner mixes the percentages very likely would be increased.

The shearing strength of a joint is greatly increased by a treatment of the surface of the old concrete, and although it may slightly increase the cost of the work, the added effect would certainly seem desirable. The results of this series show that there is no danger of leakage at a joint made in concrete of a mixture as rich as 1 : ⅔ : 1⅓, under pressures up to 40 lb. per sq. in., when the surface of the old concrete has been treated.

SCOTTISH MODE FOR THE MEASUREMENT OF REINFORCED CONCRETE WORK.

A publication has recently been issued under the above title by H.M. Stationery Office, and we reproduce below that part of it dealing with the rules for reinforced concrete work, omitting preliminary sections and the general items at the end.—ED.

GENERAL RULES.

A. The quality of materials and workmanship shall be clearly stated and the items shall be numbered for reference.

B. All temporary carpenter work required for the carrying out of the work shall be included in the Schedule for reinforced concrete work.

C. Any timbering required to be left in position shall be paid for if not so provided for in the Schedule.

D. If hoarding, sheds, stores, or other temporary work is to be included in the Schedule for reinforced concrete work, it shall be measured in accordance with the following rules :—

Generally.—(a) General descriptions shall be held to be sufficient to enable the contractor to price the items except where otherwise provided for hereafter.

(b) The rates for temporary work shall include for the maintenance and removal of same, unless otherwise stated in the Schedule.

(1) Hoardings shall be measured by the lineal foot, stating height and quality of boarding and the number of fronts and returned ends ; the price to include framing ; and if so stated for digging holes for posts and making good. Gates in hoardings shall be numbered for extra value, stating if portable, hinged, or sliding. The period of maintenance shall be stated.

(2) Plank or batten pavement shall be measured by the lineal foot stating breadth and thickness. The price shall include kerb and handrail, with or without posts, if so described. The period of maintenance shall be stated.

(3) Overhead coverings shall be measured by the lineal foot stating breadth, general description, number of closed ends, and period of maintenance.

(4) Items shall be provided for sheds, stating length, also for toolhouses, stores, shelters, and privies for workmen.

(5) Office for clerk of works shall be described stating size and any fittings required and period of maintenance.

(6) Light, fuel and attendance for clerk of works office shall be provided for, the period being stated.

(7) Fitting up, lighting, and extinguishing lamps on hoardings shall be provided for, the period being stated. The price shall include for contingent works and for supplying illuminants and maintaining lamps.

(8) Gabbart or built scaffolds and stagings shall be provided for by stating the lengths and heights requiring such scaffolds or stagings. In the case of

interiors requiring such scaffolds the dimensions of such interiors shall be given. Where such scaffolds or stagings are to be used by other tradesmen it shall be so stated.

(9) If any temporary work under this heading requires to be taken down and re-erected it shall be so described. The price shall include for any contingent works.

(10) Temporary doors and closing in of windows and other openings for protection during the progress of the work shall be numbered ; the size of openings exceeding four superficial yards to be stated.

E. All work in connection with the structural members of each storey of the building shall be stated separately and the Schedule of Quantities for each storey shall be made out in the following manner, viz.—(1st) Formwork, (2nd) Concrete, (3rd) Steel. The height from floor to floor shall be stated immediately under the headings for each floor.

F. All raking, curved and domical work shall be classed separately.

G. All work shall be measured net without allowance of any kind except where otherwise stated.

H. The price of Formwork, which, unless otherwise described, shall be held to be sawn and with plain edges, shall include for all necessary uprights, runners, braces and other supports and fixings and slack blocks, and also for easing and striking centres and taking down and removing.

SPECIFIC RULES.

FORMWORK.

Boxing.—1. Boxing for detached foundations under 8 feet square shall be numbered ; that for other foundations shall be measured in detail in accordance with the rules hereafter laid down for work of a similar nature.

2. Boxing for pillars, columns, pilasters, newals, counterforts and other similar vertical work, and also for beams, shall be measured by the lineal foot stating the shape and actual dimensions of concrete section. Isolated beams shall be stated separately. If the angles are to be shaped the number of the fillets required shall be stated and stops and mitres numbered. The number of pillars, etc., shall also be given.

3. Boxing for pillars and columns shall be measured from top of foundations or floor slabs, as the case may be, to underside of floor or roof slabs ; that for main beams between concrete pillars, etc., or walls, and for secondary beams between concrete main beams or walls. Where the ends of beams rest on brick or stone walls the wall hold shall be added.

4. Brackets, splays and swellings on pillars, columns and beams, also caps, shall be numbered stating the shape and finished concrete dimensions and the price shall include for all labour and waste.

5. Intersections of beams with stanchions, beams with beams and beams with concrete walls shall be numbered, and no deduction shall be made at same.

Centering.—6. Centering for concrete floors and roofs shall be measured by the superficial yard of net surface in contact with the concrete. No deduction, however, shall be made for openings containing 12 su. ft. and under, but openings exceeding 12 su. ft. shall be deducted. An allowance of 12 ins. at all breasts shall be given.

7. In the case of hollow floors and roofs centering shall be taken separately for the upper slab, the height of void being stated, no matter what method is employed by the contractor in forming the void. Boxing for struts between lower and upper slabs shall be described and numbered.

Note.—In the case of boxing and centering for floors it shall be stated in the Schedule if the boxing and centering for two or more floors will require to be in use concurrently.

8. Boxing for breasts shall be measured by the lineal foot, stating depth of breast, and the price shall include for fixtures.

9. Centering for plats, landings and steps shall be classed separately, stating whether the steps are plain, raking or wheeling. Boxing for stringers or the open ends of steps made in position shall be measured by the lineal foot, stating whether plain or wheeling and whether the stringer projects above or below the steps or both.

10. Where stringers project above the steps and where steps are housed in concrete walls, the ends of steps shall be numbered to allow for cutting and waste.

11. Cutting and fitting to metal stanchions and columns shall be numbered. Angular and curved cuttings shall be measured by the lineal foot of single cutting for labour and waste.

12. Centering for arched and vaulted ceilings and domes shall be measured by the superficial yard, the form stated and the height from support to springer given. Cutting at groins of arched and vaulted ceilings and at junction of ribs and slabs of domes shall be measured by the lineal foot for labour and waste as in Clause 11. Boarding shall be taken for the upper surface and stated separately.

13. Centering for arches over openings shall be numbered and the span, rise, breadth on soffit, form and height from support to springer given.

Sheeting.—14. Sheeting for walls shall be measured by the superficial yard of net surface in contact with the concrete, both sides being measured. No deductions shall, however, be made for voids in sheeting containing 12 su. ft. and under, but voids exceeding 12 su. ft. shall be deducted in full. Angular and curved cuttings shall be measured by the lineal foot for labour and waste as in Clause 11.

15. Sheeting shall be measured for the upper surface of sloping slabs or beams which are inclined at more than 15 deg. to the horizontal, and stated separately.

16. Boxing at openings, ingoings, edges and returns shall be measured by the lineal foot stating the depth. If the angles are to be shaped the number of fillets required shall be stated and stops and mitres numbered.

17. Fillets on sheeting shall be measured by the lineal foot and stops and mitres numbered.

18. Sheeting for hollow walls shall be taken separately for each face of concrete, the width of cavity being stated. Boxing for ties or struts between outer and inner slabs shall be described and numbered.

19. Boxing for projected courses and eaves, also for sills, facings and mouldings, shall be measured by the lineal foot with description, giving projection and height of concrete course. If such course is moulded the description shall state if there is any undercut or quirk mouldings. Blocks, modillions and dentils shall be described and either numbered or measured by the lineal foot, the centres being stated.

20. Mitres, butts and stop ends of all moulded work shall be numbered.

21. Boxing for holes through walls and floors and sockets for standards or balusters or holes for bolts and other fastenings shall be classified and numbered stating shape.

22. Boxing and fillets forming grooves and chases shall be measured by the lineal foot.

23. Boxing for fireplaces and oncomes shall be described and numbered. Boxing for flues shall be measured by the lineal foot stating size and bends and swellings numbered. Boxing for ventilation openings or openings to flues shall also be classified and numbered.

Panelled Work.—NOTE.—Panelled work shall be held to be either raised or sunk above or below the general surface of slabs to which it is attached. Plain slabs between pilasters and beams are not to be treated as panelled work.

24. Panelled ceilings, walls, pillars, columns, pilasters, beams, etc., shall be classified separately and measured for the plain surface over the whole area, as hereinbefore provided for. All boxing for edges, checks, rebates, ingoings, mouldings, etc., shall be measured by the lineal foot. Mitres, butts and stop ends shall be numbered.

CONCRETE WORK.

NOTE.—In measuring concrete no deduction shall be made for volume of steel.

Foundations.—25. Concrete in foundations shall be measured by the cubic foot.

Stanchions.—26. Pillars, columns, pilasters, newals, counterforts and other similar vertical work shall be measured by the lineal foot stating shape and dimensions of section. The length shall be taken from the top of the foundation or floor, as the case may be, to the top of next floor or roof.

27. Brackets, splays and swellings on pillars, columns, and beams and also caps shall be numbered and the dimensions stated.

Beams.—28. Beams shall be measured by the lineal foot in the manner described in Clause 3, stating the breadth and the depth from the underside of the floor. Isolated beams shall be stated separately.

Walls.—29. Walls shall be measured by the superficial yard stating the thickness. All openings shall be deducted except as provided in Clause 31.

30. Hollow walls shall be measured as Clause 29, keeping outer and inner slabs separate. Ties and struts between slabs shall be numbered.

31. No deduction shall be made from the concrete for ventilating openings and such like 2 sq. ft. and under in area.

32. Vent linings shall be measured by the lineal foot stating size.

Floors.—33. Floors shall be measured by the superficial yard, stating the thickness The dimensions shall be taken over the beams and through columns ; all openings shall be deducted except as provided for in Clause 31.

34. Hollow floors shall be measured as above, keeping the lower and upper slabs separate. Struts between slabs shall be numbered.

Roofs.—35. Flat roofs shall be measured in a similar manner to floors, and if hollow, in a similar manner to hollow floors. Sloping roofs shall be classed separately and the pitch shall be stated when it exceeds 15 degs. to the horizontal.

36. If the floors or flat roofs are to be formed with a declivity in additional thickness, such additional thickness shall be measured separately by the superficial yard, the average thickness being stated.

Arched and Vaulted Ceilings.—37. Arched and vaulted ceilings shall be measured by the superficial yard of extrados, stating the thickness. Where the slabs of arched or vaulted ceilings and domes vary in thickness from the springing to the crown, the concrete shall be measured by the cube foot.

38. Ribs of arched and vaulted ceilings and domes and arches in walls shall be measured by the lineal foot of extrados stating shape and dimensions of section.

Base, Belt, and String Courses, etc.—39. Projected courses and eaves, also sills, facings and mouldings formed on concrete walls shall be measured by the lineal foot at the extreme lengths and the sectional dimensions stated. Mitres, butts and stop ends shall not be taken under concrete work.

Stairs.—40. Stringers shall be measured by the lineal foot stating whether below or above the slab or both, and also stating shape and dimensions of cross-section and outline.

41. Steps cast in situ shall be measured as follows:—The reinforced sloping slabs under the degrees shall be measured by the superficial yard, the thickness stated normal to the slope and classified according to outline of soffit.

The degrees of steps above slabs shall be measured by the lineal foot stating number, and unless otherwise stated it shall be understood that the breadth of tread shall not exceed 12 ins. in straight and 16 ins. in wheeling steps. The price of steps shall include for finishing the tread, riser and exposed end of step and edge of slab under, if so described.

42. Plats and landings shall be measured by the superficial foot stating thickness and the price shall include for finishing the upper surface, if so described. Finished edges shall be measured by the lineal foot.

43. The finishing of the soffits shall be measured by the superficial yard, classified according to outline.

Pre-cast Concrete Work.—44. Sills, mullions, transomes, lintels, copes and other pre-cast work shall be measured by the lineal foot. Corbels, trusses, balusters and such like shall be numbered. It shall be stated if the prices are to include for setting.

45. Pre-cast steps shall be numbered and classed as straight or wheeling, built or hanging, and if pen checked it shall be so stated. The full length including the wall-holds shall be stated. Straight steps shall not exceed 14 ins. in breadth and wheel steps 18 ins. in breadth unless otherwise stated. Pen checked steps shall not exceed 8½ ins. and plain steps 7 ins. in thickness unless otherwise stated.

46. Pre-cast plats shall be measured by the superficial foot as above.

47. It shall be stated if the price of pre-cast steps and pre-cast plats is to include for setting.

48. All pre-cast work shall include for moulds and for such finishing as shall be described.

Holes, Grooves, and Chases.—49. Holes cut through walls and floors and sockets for standards or balusters shall be classified and numbered, it being stated if price is to include for making good.

50. If holes formed in concrete are to be made good they shall be classified and numbered.

51. Cutting grooves and chases shall be measured by the lineal foot.

Setting Bolts and other Fastenings.—52. Setting bolts and other fastenings shall be numbered. If they are to be cut out for and built in, it shall be so stated.

Finishing.—53. If the exposed surfaces of concrete work other than hereinbefore provided for are to be rubbed, floated or otherwise finished after the boarding is removed, the surfaces so finished shall be measured by the superficial yard. Arrises on surfaces floated or otherwise finished shall be measured by the lineal foot. No arrises shall be allowed on rubbed work.

54. The upper surfaces of floors and roofs, unless otherwise stated, shall be held to be shovel finished. Floating or other finishing for surfaces of floors shall be measured by the superficial yard, it being stated if such finishing is to be carried out simultaneously with the laying of floors.

55. If the surface of concrete work is to be picked before being finished, it shall be so stated along with the finishing.

56. If the work covered in Clause 39 is to be floated or rendered in cement instead of being cast with the solid concrete, it shall be measured in accordance with the mode for the measurement of plaster work.

STEEL.

57. The prices shall include for forming cranks, bends, knees, hooked or fish-tailed ends and all other labour and also for tying wires up to 18 gauge unless otherwise specified, ferrules, and fixing in position.

58. Steel bars and rods shall be classed separately according to size or diameter of section and the various weights shall be stated in cwts. Bars under 6 ft. long and over 30 ft. long shall also be classed separately.

59. Stirrups and ties shall be classed separately and stated by weight.

60. Spiralled rods shall be classed separately and stated by weight.

61. An allowance of 2½ per cent. shall be added to the weight of steel to cover the mills rolling margin.

62. Expanded steel and woven wire mesh or other similar reinforcement shall be measured by the superficial yard of net area covered, stating amount of overlap and giving weight of sheets per square yard, gauge of wire or otherwise full description of reinforcement sheets to be used. If the sheets are to have fastenings, it shall be so stated and the fastenings described. The price shall include for overlaps, square cuttings and waste. Angle cuttings shall be measured by the lineal foot for labour and waste.

63. Wire hooping to steel or cast-iron columns and girders shall be measured by the lineal foot of the stanchion or beam to be hooped, stating the section of the stanchion or beam, the gauge of the wire and the distance apart from centre to centre.

SPECIAL FLOORS.

Special Floors.—64. In the case of special floors resting on steel beams and walls, which cannot be definitely specified, the system of construction being left open to the tenderer, the work shall be measured by the superficial yard of floor areas including wall rests, and shall include for all centering, steel, concrete or other material which may be necessary for the complete construction of the floor. Deductions shall be measured net, but an item shall be given for trimming of all openings, giving daylight sizes. Finished edges in all cases shall be measured by the lineal foot.

Clauses 36 and 49 to 55 inclusive of foregoing mode are also applicable to Special Floors.

PILING.

Piling.—65. A general description of the nature of the site (i.e., whether level or irregular) shall be given and the time in which the work has to be executed stated ; also whether the work is " tidal " or not. A description of the strata through which the piles are to be driven shall be given, or reference made to plans showing record of bores. The allowable weight of hammer and the set to which the piles are to be driven shall be clearly stated.

66. Piles shall be classified separately according to length and section, stating the number of each. They shall be measured by the lineal foot of cast length, price to include conveyance to the site. If piles can be cast at the site this shall be stated

67. The number of moulds required for each class of pile shall be stated, the price for each mould to cover for all temporary work in connection with casting.

68. Shoes shall be described and numbered, the weight being given.

69. Items shall be given for handling and driving each type and size of pile, the number and depth being stated.

70. Cutting heads of piles to required level shall be numbered.

71. Provisional quantities for boarding, concrete, steel rods and links required for lengthening piles in situ shall be given in addition to the foregoing items.

72. Steel reinforcing shall be classed and measured as in Clauses Nos. 57 to 60 inclusive.

73. Trial piles shall be stated separately and measured as above, stating position of each.

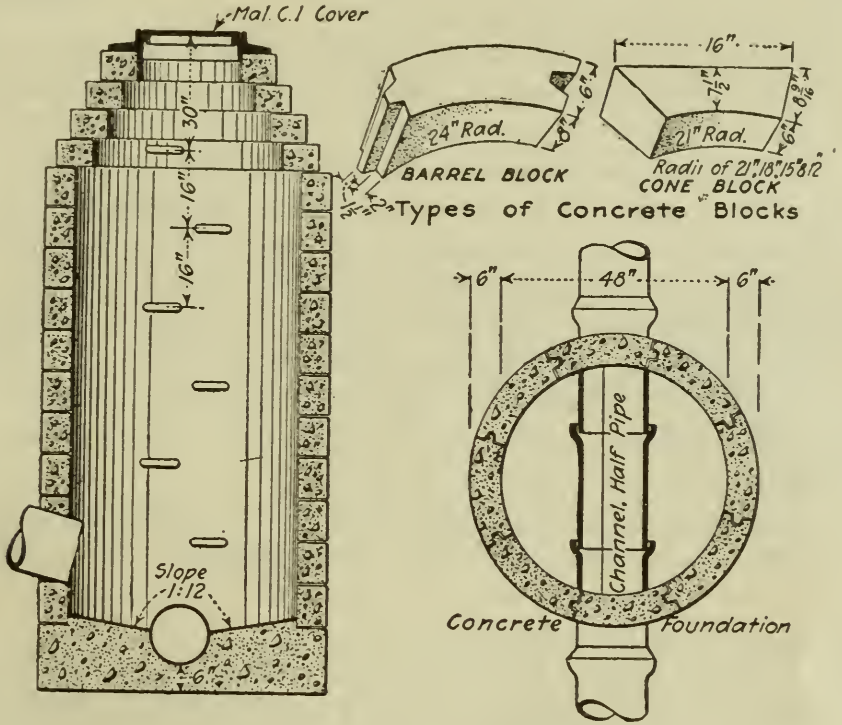
Large Surfaces against Ground in Excavation.—74. Where large surfaces of reinforced concrete rest on the ground in excavation, an item shall be given for 3 ins. additional thickness of concrete over the constructional thickness and measured by the superficial yard and stated separately.

75. In no case is it to be assumed that boarding is not required where reinforced concrete surfaces come against the vertical sides of excavation.

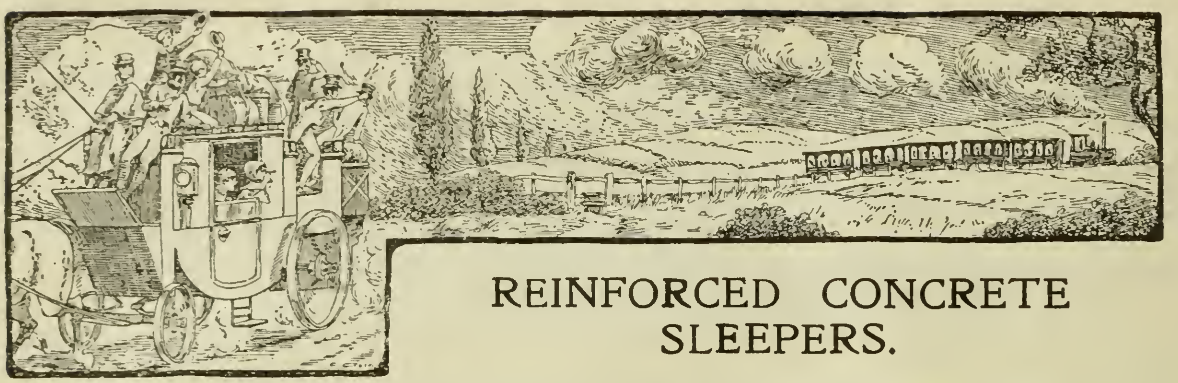
NOTE.—The two foregoing rules do not apply to mass concrete work.

MEMORANDUM.

Concrete-Block Manholes for Pipe Sewers.—Concrete-block manholes for pipe sewers, as built at Terre Haute, Ind., in accordance with the accompanying illustration, cost 40c. each, or about $8 per foot of height. The blocks are made of 1 : 2 : 4 concrete, with 10 per cent. of hydrated lime added for waterproofing. The floor of the manhole is sloped to obviate the remaining of sewage in the manhole when the sewer is running over half full. The same general design is used for catchbasins. The design shown is that of R. A. Koerner, City Civil Engineer, Terre Haute, who was led to make it by the exorbitant price demanded for brick.



SHOWING DETAILS OF CONCRETE BLOCK MANHOLES.



REINFORCED CONCRETE SLEEPERS.

Readers of this journal will recall the many references that have been made in these pages to concrete railway sleepers as well as the extensive reviews on the subject presented in our issues of July and October 1917. We now present below some particulars of a new type of concrete sleeper which has been submitted to trial on the Italian State Railways, as well as a brief note with diagram of a reinforced concrete sleeper designed by Mons. Muzak of Brussels.—ED.

In a recent number of *Il Cemento* it is reported that the Italian State Railway is experimenting with a new type of reinforced concrete sleeper which is designed to possess as far as possible the same properties and resist the same strain as the wooden ones. The following is a short abstract of the article which appeared in that journal, together with the illustrations :—

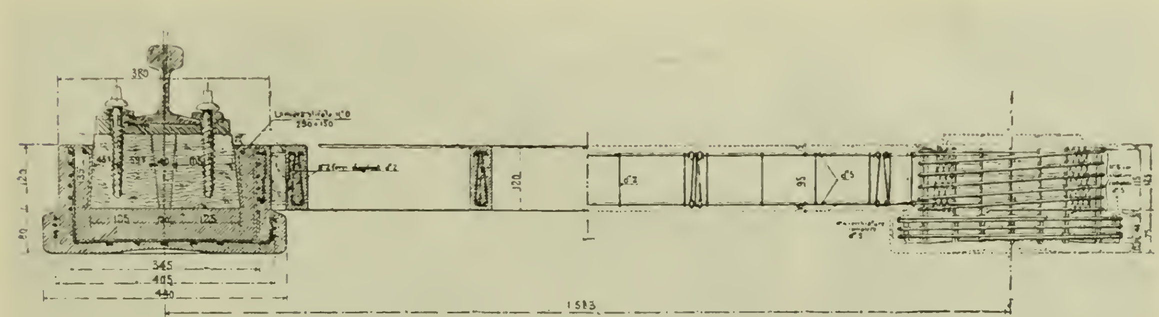
In considering the direction and intensity of such strains it is well to recall the remark made by the Railway Engineers' Commission, presided over by F. Benedetti, to the effect that, on the passage of a train over a sleeper, the latter only receives a part of the load itself, as the neighbouring sleepers contribute to bearing it. The fraction of the load which must be considered as bearing on one sleeper varies according to the distance between the sleepers, the rigidity of the reinforcement, and the distance between the wheels of the locomotive, carriages, etc. Calculations have shown that the maximum bending movement to which the sleeper can be exposed when the maximum weight of the moving load is 17 tons could be calculated at about 150 ton inches, but such a result cannot be considered as being strictly correct, as the supposition of a continual loading of the sleeper on the bed is not always realised.

On the other hand, as a timber sleeper of ordinary dimensions satisfactorily resists the strains and pressure to which it was exposed, it was thought advisable to be guided by the resistance of such a sleeper when calculating the bending load and breaking strength of the proposed sleepers.

To equal an oak sleeper of the ordinary dimensions used on the Italian Railways, namely 10 in. by 5½ in. with an average breaking strain of 8,400 lb. per sq. in. it is easy to calculate that for the reinforced concrete sleeper of equal dimensions the initial reinforcement should have a section of one-tenth of the total section of the concrete, i.e., there should be a quantity of reinforcement which is practically inadmissible for resisting such a moment, whilst if the reinforcement were contained within narrower limits and were made, for instance, of ½ in. round iron the maximum strain which the sleeper would withstand would be 8,000 lb. per sq. in. for the concrete and 140,000 lb. per sq. in. for the iron. In such a sleeper there would be nearly double the weight of reinforcement which could be practically allowed in order that the cost should not be excessive, and even then the strains would be nearly treble those which may cause the breaking of the reinforced concrete sleeper, considering such limits for the concrete to be about 2,800 lb. per sq. in.

From the foregoing conclusions it was concluded that a reinforced concrete sleeper of the same shape and dimensions as the wooden ones could not be as strong as the latter, and that it was therefore advisable to consider new shapes for concrete sleepers, so as to reduce within the narrower limits the bending moments which affect the ordinary sleepers.

The new type of sleeper shown in the accompanying illustrations is formed of three distinct parts, viz., two ends or bearings and the bars connecting them together. Each bearing is a cylinder which stands on a base of the same shape but of larger diameter; the connecting bars are formed of two parallel ties joined together and of the same height as the upper parts of the bearings, and placed to correspond with them, so as to be at the same height above the ground level as the width of the lower cylinders and thus miss the footboards and other projections during the passage of trains. In the upper part of the bearing is an opening in which the apparatus for attaching to the rails is placed, and consisting of three cones adherent to each other, their heads projecting above the heads of the bearing and constituting the supporting surface of the bearing plate. This arrangement prevents any contact of this plate with the concrete of the bearing, and therefore eliminates any risk of abrading or grinding away of the concrete. The plugs of the plates are screwed to the two outside cones of each bearing in



Half Longitudinal Section. Fig. 1. Half Plan of the Reinforcement.

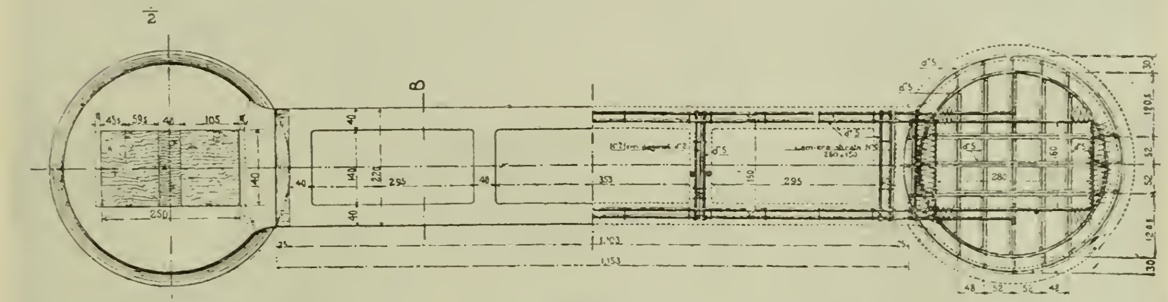


Fig. 2.

Half Horizontal Section. Half Section Showing the Reinforcement.

(*The dimensions are in millimetres*).

the proper position according to the type of plate and the gauge. A preliminary lot of 100 sleepers was made from July 1st 1916 to September 16th 1916. These were not exactly like those shown in the illustrations, as the connecting bars of the bearings had only one traverse connection. These sleepers were allowed to season for two months before being laid on a straight track with an incline of 9·6 per 1,000 with an average of 20 trains passing over it in 24 hours ; the maximum speed allowed is 60 miles per hour, and several trains with unusually heavy locomotives have gone over it.

The foundation of the track is composed of fine gravel mixed with earth ; it may be considered of medium quality. The new sleepers have withstood and are still withstanding a continual heavy traffic without anything abnormal taking place either with regard to the level of the gauge of the track or the fastening of the rails to the sleepers, the last named remaining perfectly firm.

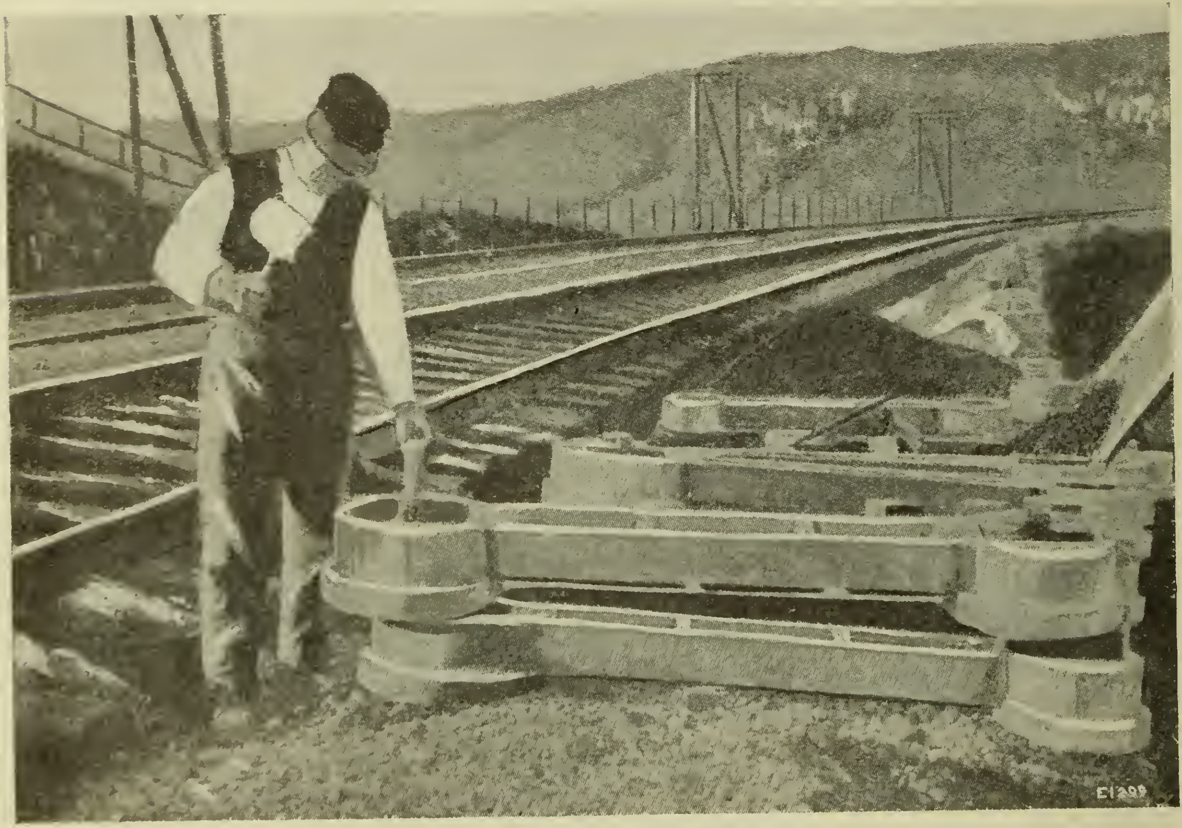


Fig. 3. Showing Sleepers Ready for Laying.

Unfortunately, from the first many of the sleepers showed cracks in the connecting bars and these developed in some bars until the latter appeared to be wearing away, though these defects in no way prevented the bars from doing their work, viz., to maintain the right gauge between the bearings.

In April 1917, after the sleepers had been in use for five months, the Administration of the State Railways agreed that the trial had fully proved the fitness of the new sleepers, and that the insufficient resistance of the distance pieces (which was the only weak point which had been detected), could be easily remedied. A second lot of sleepers—2,000 in number—was then placed in continuation of the first hundred in a part of the track containing two curves of 1,600 ft. and 1,500 ft. radius, this second lot of sleepers being improved by the use of much closer connecting bars with more joints. The concrete of the connecting bars was also made independent of that of the bearings, by means of special concrete joints destined to give the necessary elasticity to the sleeper, and allowing for the slight twisting movements to which the sleepers are exposed on the passage of the trains as a result of the uneven pressure on the bearings. Slight alterations were also made in the arrangement of the reinforcement of the bearings.

The construction of the 2,000 sleepers was commenced on June 11th, 1917 at Naples, by the firm Ing. Comm. Carratu, which had supplied the first lot, and were ready by the end of January 1918.

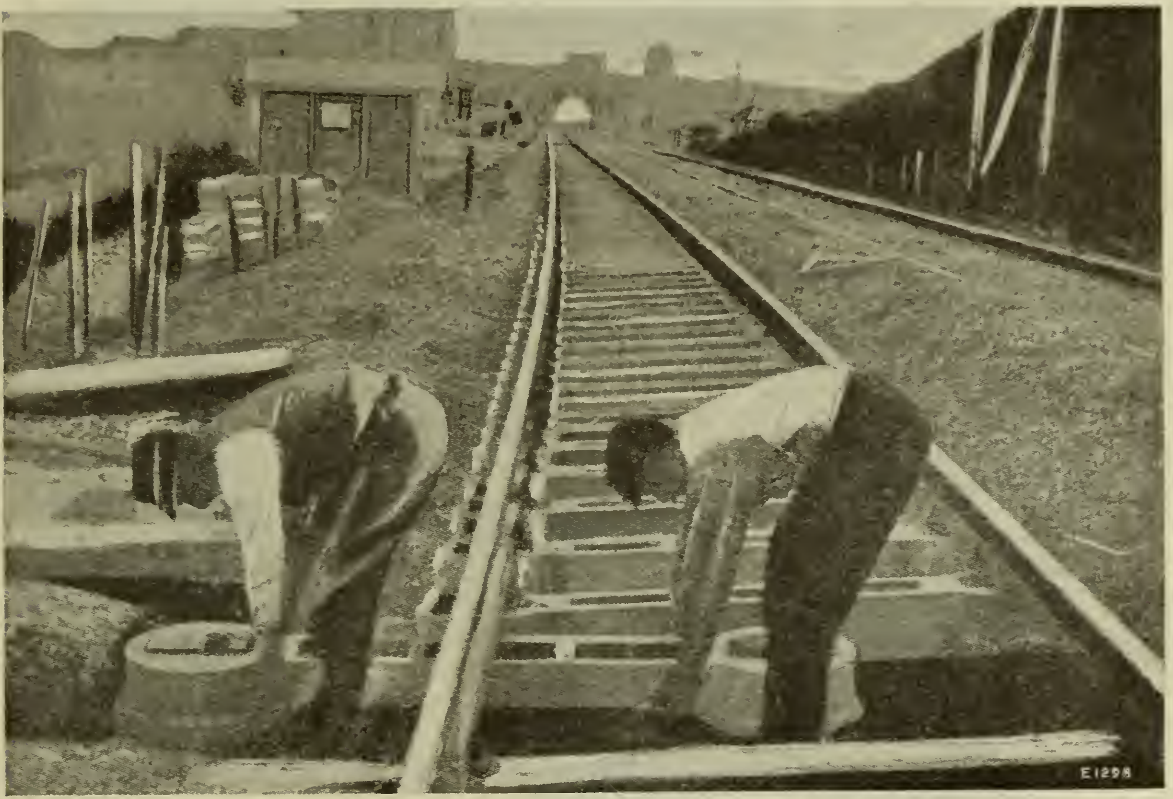


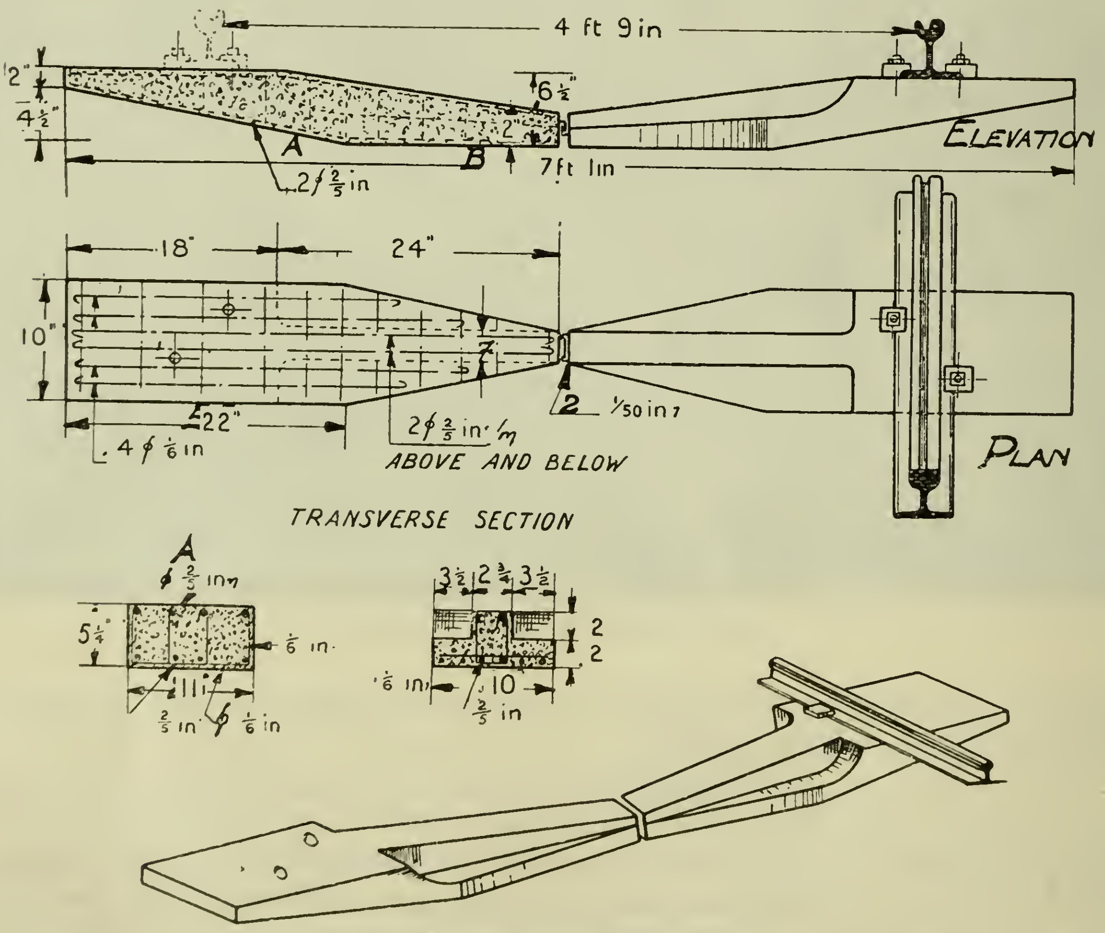
Fig. 4. Showing the Laying of Sleepers.

. The preparation of the reinforcement was done almost entirely by women. The finished reinforcement was then placed in moulds into which concrete was poured and pressed. The moulds were removed gradually, the parts relating to the bearings being withdrawn on the second and those surrounding the connecting bars on the fourth day. On the tenth day the sleepers were seasoned under cover for two months, after which they were loaded on to railway trucks and sent to the place where they were to be used. Thus, in various stages, the manufacture and laying occupied from the middle of December 1917, to the middle of September 1918. A platelayer fixed the cones on the special parts of the bearings, fixing the outer cones first and then the centre one between the others, striking it with a wooden mallet (Fig. 3). The same man then levelled the heads of the cones with a hatchet, thus preparing the bearing surfaces of the plates (Fig. 4). The sleeper is then put in position in a similar manner to that used with the ordinary wooden sleepers, the new sleeper being laid under the rails in the required position (Fig. 5), and the plugs are then screwed down as for other sleepers.

From the time of laying up to the present day, a little over two years, the sleepers have given satisfactory results, and no defects have been discovered.

CONCRETE RAILWAY SLEEPERS (MUZAK SYSTEM)

In order to ensure the requisite elasticity which is so essential in railway sleepers, V. Muzak, of Brussels, has devised an arrangement, shown in the accompanying illustrations, in which the sleepers are in two parts with a central semi-rigid joint, the shape of the sleepers being different from those usually employed.



Concrete Railway Sleepers (Muzak System).

He claims that this arrangement requires a minimum of reinforcement, yet provides a maximum resiliency and a good distribution of the load on the ballast. The inclination of each half of the sleeper gives it a tendency to slip towards the centre and the pressure thus produced is neutralised by the movement of the joint. These sleepers cost 8 francs each at Brussels.

THE USES OF ASBESTOS CEMENT AT THE ROYAL AGRICULTURAL SHOW, CARDIFF.

Some Farm Buildings.

In describing the concrete exhibits at the Royal Agricultural Show, Cardiff, last month, we briefly referred at the close of our article to the asbestos-cement exhibits of Messrs. Turner Bros., of Rochdale, of which we give a short description below.—ED.

THE PRACTICAL APPLICATION OF ASBESTOS-CEMENT BUILDING MATERIALS FOR FARM AND ESTATE BUILDINGS.

In this connection we would recall the articles which appeared in this journal some months ago, describing this material and illustrating its use for various purposes.

The world's position with regard to housing and the many schemes of reconstruction, most if not all of which involve building on an extensive scale, induced Messrs. Turner Bros. Asbestos Co., Ltd., to depart from their usual policy and demonstrate to the great agricultural industry what had already been done in the adaptation of asbestos-cement building materials for the many purposes demanded by the industry.

The exhibits at Cardiff comprised shippon, cart shed and hay barn, 42 ft. by 31 ft.; also poultry houses.

Beside the actual structures shown, illustrations in colour were distributed of a variety of buildings erected in the material including bungalows and shooting boxes, farm buildings and labourers' cottages, estate outbuildings, a village hall, a gymnasium and clubhouse, pavilions, go-downs for export use, Dutch barns, covered stock yards, cart and implement sheds, garages, poultry farm structures such as field houses, chicken coops, intensive and incubator houses, etc. An interesting example showing how the material can be used for industrial buildings was that of the Dunlop Cotton Mill, Ltd., of Castleton, nr. Manchester, with a total area of roofing before extension of ¼ million sq. ft., all in "Aegis" asbestos-cement sheets.

A Bungalow.

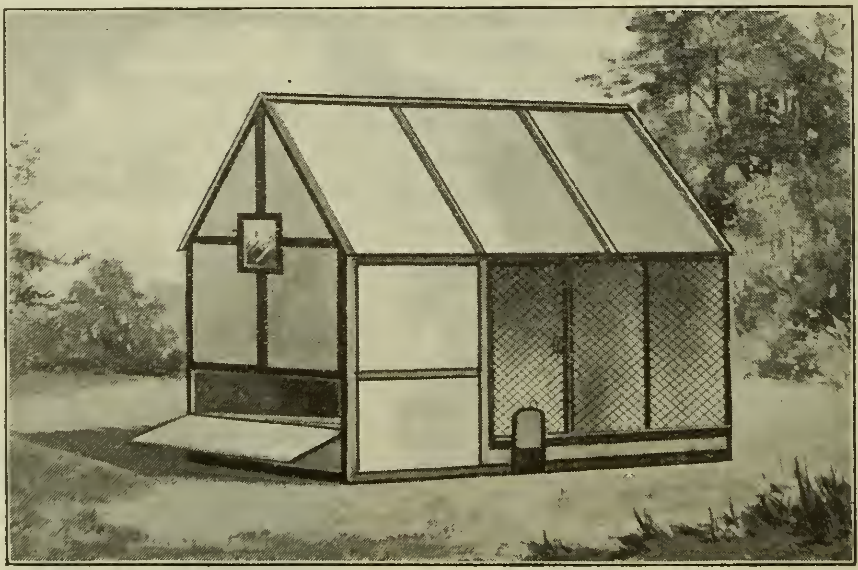
Some Dwellings with Asbestos Cement Roof Slabs.

Shortly stated, asbestos-cement building materials for agricultural purposes particularly are superseding corrugated iron and boards and felt. In a second product, and one which is becoming very popular, it is marketed in corrugated form, and under this heading is termed Trafford tiles and sheeting, the sizes for the roofing being 4 ft. by 3 ft. 8 in., and for the vertical work, *i.e.*, sides of buildings, 6 ft. by 3 ft. 8 in. The flat sheets, however, are also used for inside work, lining walls and under drawing roofings, replacing lath and plaster. When used for outside in either the one form or the other, the sheets, slates or tiles require no tarring or painting.

For some technical details regarding this material we refer our readers to our issues of December, 1918, and January, 1919.

All the asbestos-cement building materials are economical in application and maintenance, and they also possess a very high degree of fire-resisting qualities with strength and elasticity.

The illustrations here given will indicate to some extent in how many ways the material lends itself to various forms of structures, and fuller particulars are available on application to Messrs. Turner Bros., Rochdale, Lancs.



A Poultry Field House.

"CONCRETE SHIPBUILDING"

It is our intention to discontinue this series as a special supplement, and to incorporate it in each issue of the magazine.—ED.

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER V.—(*Continued*).

REMOVING THE SHUTTERING.

The removal of the shuttering or formwork is known as *striking.* It should not take place until the concrete is sufficiently hard to be self-supporting. The lower portions of the shuttering may be removed within a week of the completion of the placing. The length of time which elapses must, however, be left to the discretion of the man in charge of the work, and in frosty weather the forms may remain for three weeks or more. The longer the forms remain in place the safer will be the concrete. Some of the simpler forms may, in summer, be removed as early as three days after placing, but this is somewhat risky.

The striking of centering is a most important and responsible duty, as if done too soon or unskilfully it may result in the collapse of the structure and in serious loss of life. Many of the fatal accidents in connection with concrete—particularly in America—have been caused by too early removal of the centering and by loading the structure before the concrete was properly hardened. Concrete is often used for bridges, floors, and in other positions where the weight of material with no support immediately beneath it is very great, so that the dead weight of the structure alone may be more than half that of the live load it is designed to carry. Consequently, the premature removal of the forms is always risky, and too much care and skill cannot be exercised in preventing accidents due to this cause.

The greatest care should also be taken in removing the forms not to jar, shake or tear the concrete, as it will not be fully hardened and may easily be damaged. After the removal of the forms the concrete should be protected from the sun's rays, rain, dust and wind by canvas, burlap or sheeting, and its surface should be kept wet by sprinkling water on it twice daily for five or six days. This treatment is necessary to prevent the outside of the mass drying more rapidly than the inside, and so causing strains. In summer weather and tropical climates this watering of the surfaces should be done with care and intelligence. If sheeting or burlap is used this should be wetted as well as the surface of the concrete.

The forms, after removal from the structure, should be at once cleaned by means of a short-handled hoe, care being taken not to gouge the wood.

SURFACE TREATMENT.

In order to secure a minimum resistance to her passage through the water, as well as to improve her appearance and render the concrete more impervious, it is desirable that the outer surface of the vessel should be smoothed. If—as is generally recognised as being desirable—nothing resembling a finishing coat is to be applied, the most that can be done is to scrub the surface, first, with a wet brush, and afterwards with carborundum or other abrasive blocks. A mechanical surfacing device may be used, if desired, especially for such large surfaces as are involved in shipbuilding. The use of the abrasives is not advisable, as they tend to remove the dense surface or skin produced when concrete is " placed " in a smooth mould and to expose the more porous material beneath. Probably the most effective treatment consists in smoothing the surface as indicated and then rubbing it with a slurry containing equal measures of cement and fine sand or brick dust, so as to fill in all the interstices and to restore, as far as possible, a skin of dense concrete to the parts from whence it has been removed.

If the formwork is well made and its face is carefully planed, and treated with oil or wax, and the concrete is properly prepared and well tamped, the surface of the vessel after the removal of the forms will be smooth enough for all practical purposes, and it will be more impervious and less likely to disintegrate than if it is subsequently subjected to any surface treatment. The chief disadvantage of most surfacing materials is their liability to scale in course of time.

CHAPTER VI.

LAUNCHING.

ALL vessels are launched long before they are ready to make a voyage. The launching of a large ship requires so much care, for any accident might do her an immense amount of damage, that she is launched while as light as possible. Her heavy engines and boilers, her masts and funnels, all the fittings of her cabins, and many other things are fixed after she is safely afloat.

A concrete vessel may be launched in four ways : (i) end-on, (ii) broadside-on, (iii) floating from the dry dock in which she is built, and (iv) by lifting her and then lowering her gradually into the water.

(i) The customary method is that first mentioned, the vessel being lowered down a suitably-built incline or slipway into the water. It is probably the most suitable method for large steel vessels, the hulls of which, at the time of launching, are complete as far as intrinsic strength and resistance to water are concerned. A concrete hull, on the contrary, will continue to increase in strength during a period of many years, and at the time of launching it may only have attained three-quarters of the ultimate strength. Hence, a method well adapted for steel vessels is not necessarily the most suitable for those made of concrete. On the other hand, end-on launching usually enables very large vessels to enter the water more steadily and with less risk of capsizing than when they are launched broadside-on.

A freshly-built concrete hull usually rests on the shuttering used in its construction. This is gradually replaced by " launching ways " composed of lines of solid blocks of timber extending along each side of her. The two " ways " are braced strongly together by bars and bolts passed under the vessel's keel, so that they will not be forced apart when she begins to move and all her weight rests on them. These are the " fixed ways."

Then a " sliding way " of timber is laid on the top of each fixed way ; and, finally, built up on the sliding ways are large tapered logs. A framework called a " cradle " is also built up near the stem and stern of the vessel in order to support her where her sides curve inward from the " ways." Before the sliding ways are laid on the fixed ways, their under sides, as well as the upper sides of the fixed ways, are thickly covered with grease such as tallow, soft soap and train oil. For a large ship several tons of grease will be required.

Then, some hours before the time fixed for the launch, the work of " ramming-up " begins. The tapered blocks above the sliding ways are wedged tight all along the vessel's length, thus taking much of her weight off the keel blocks and bilge blocks on which it has been resting for so many months. These can then be struck away with heavy mallets.

The weight of the vessel then rests entirely upon the cradles and the ways, and all is ready for her to slide down into the water. She does not do so at once, because the sliding ways are prevented from slipping down the fixed ways by a " trigger " held in position against each sliding way by a powerful hydraulic ram.

When all is ready a lever is turned which releases the pressure on all the triggers and withdraws them. The vessel then moves on the greasy sliding ways down the slope, carrying the sliding ways with her. A portion of the sliding ways and cradles fall away from the vessel as soon as she enters the water, and are later towed ashore. If the " ways " are not most carefully prepared it may happen that when the vessel enters the water one-half of her length may be entirely supported by the water before the other half has dropped off the ways ; she will then hang on the " ways " and there will be great trouble. Or, as the bow drops off the " ways " into the water, it may strike against the edge of the launching " slip " and particularly in the case of a steel vessel great damage may be done.

When all goes well, as is usually the case, the ship glides smoothly down and is afloat, but the possible dangers of the launch are not quite over even yet. The vessel will have gained considerable speed or *impetus* in sliding down the " ways " and means must be taken to check and prevent her from going too far.

This impetus can be checked in several ways as soon as she is afloat. Cables may have been previously attached to her sides and also to enormous weights in the yard, or anchors may be dropped as soon as she is afloat. Steam tugs will then be attached to her and will guide her to the " berth " where she will be fitted up with such engines, etc., as may be required.

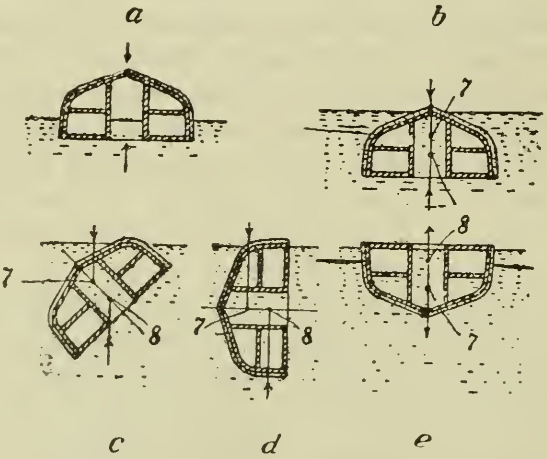
The launching of a large vessel is always fraught with anxiety, and this is increased in the case of concrete ships by the inexperience of the naval architects with respect to concrete and by the fact that a concrete hull weighs nearly twice as much as a steel one of the same carrying capacity; consequently the supporting blocks must be correspondingly stronger. It is also advisable to arrange some internal shoring in the hull.

To obviate the undesirable necessity of pile-driving in the channel where the vessel is being built, T. G. Owens Thurston suggests that the standing ways beyond the sea-wall should be supported on specially designed concrete pontoons which are towed from one berth to another, and when in the necessary positions are sunk by being flooded through sluice valves arranged in the sides for that purpose, so that, in use, they rest on the bed of the channel.

Generally speaking, the severe conditions unavoidable in this method of launching provide an adequate test of the vessel's ability to withstand any stresses she may be called upon to meet under ordinary conditions of service.

As an instance of the remarkable ability of ferro-concrete vessels to withstand the strain of launching under unfavourable conditions, the case of a vessel, 125 ft. by 22 ft. by 13 ft., launched early in 1918 at Montreal may be mentioned. The completion of the vessel was delayed by some hidden weakness in one of the timbers forming the launching ways, the result being that during the launch the ways collapsed at one end, leaving the hull half in the water and half on land. In order to force the vessel into the water, the ground was excavated and powerful jacks were employed. This operation placed the concrete under far greater strain than any for which it was designed, and constituted a very severe test of the strength of the hull. The builders state that the construction withstood the strain without showing the least indication of any injury.

W. Pollock has calculated that a Thames " swim " barge, constructed by his firm, which is 77 ft. by 21 ft. 6 in. and has a depth of 7 ft. 3 in. with a deadweight capacity of 130 tons, can (*a*) be supported light by one transverse support across the centre of the bottom, and (*b*) when loaded she can rest on a " camp shed " high and dry, with one-third the length overhung, or (*c*) still in a loaded condition, be left across a small river or canal, with each end resting on a bank and one-third of the length in the centre entirely unsupported.



161. Diagram showing how Vessel rights itself after launching.

An ingenious system of launching concrete vessels is used by the Porsgrund Cementstöperi A S of Porsgrund, Norway. The hull is built keel uppermost on a kind of sledge and slides on this, entering the water in a perfectly stable position *a* (*Fig.* 161). When fully waterborne, a small boat is rowed alongside, and from this air-cocks in the concrete hull are opened so as to admit water and cause the hull to lose buoyancy and attain to position *b*. This position is unstable, as the centre of gravity lies near the point 7, with the result that the hull begins to rotate—slowly at first, then more rapidly and afterwards slowly—until the hull is fully righted and is in position *e*.

This method of launching is illustrated in the accompanying photographs, *Fig.* 162 showing the inverted hull entering the water, *Fig.* 163 showing it at an early stage in the rotation, *Fig.* 164 when half righted and *Fig.* 165 the completely righted hull. When in the position shown in *Fig.* 165 the hull is quite stable and the water in the flooded compartments is then pumped out, the inner core removed, and the vessel completed in the usual manner. The core is used in the construction of other vessels.

(ii) *Broadside launching* is considered by some firms to be preferable to end-on launching, particularly if the building berth and foreshore has to be built on ground which has had to be heavily piled. It is chiefly used where the waterway is not sufficient in width to permit of end-on launching. Thus, the barges at Gloucester are launched broadside on ways specially designed for the purpose because of the narrowness of the canal at the shipyard.

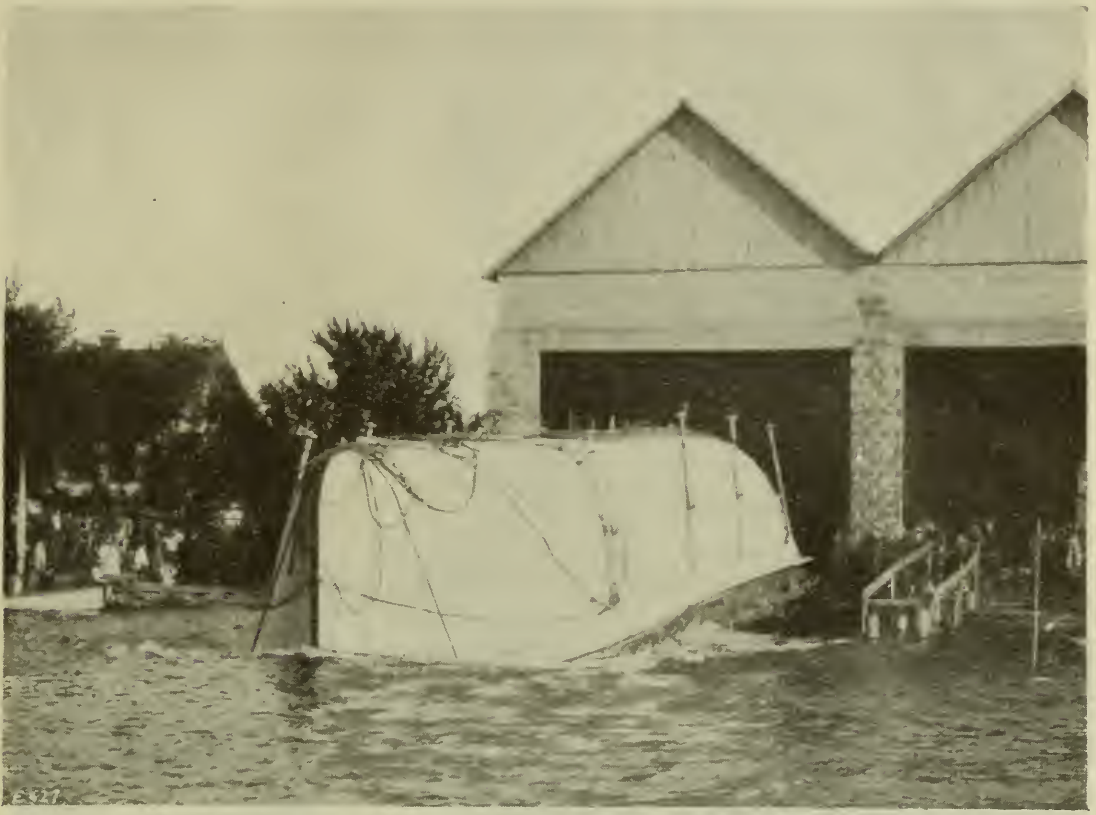


Fig 162. Inverted Vessel entering the Water

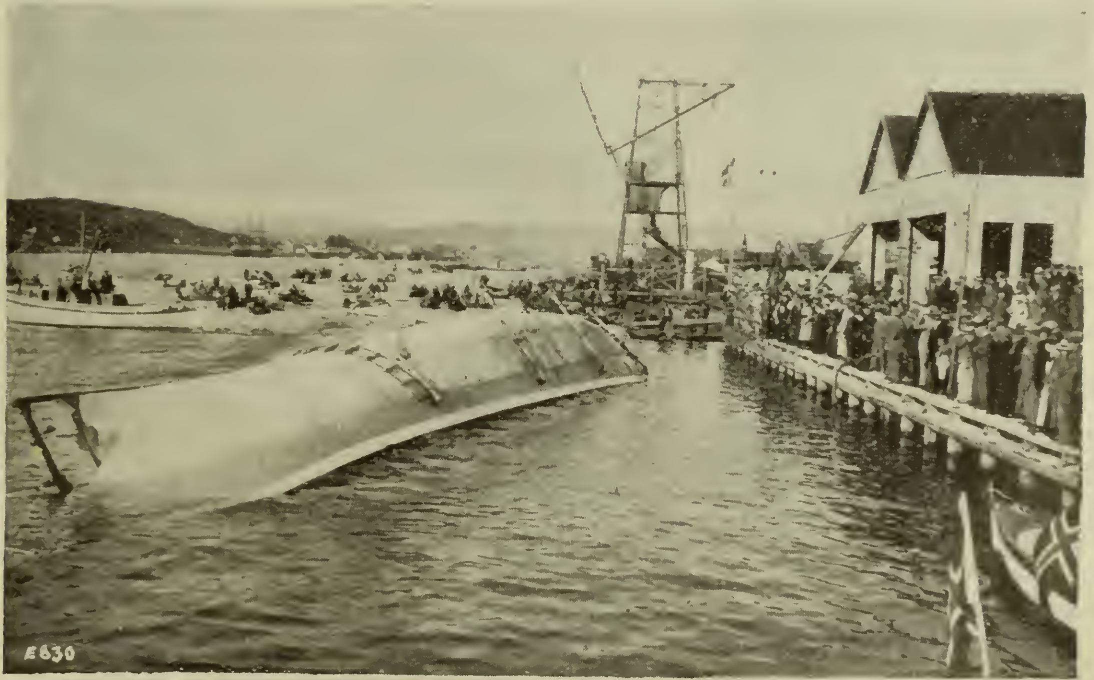


Fig. 163. Vessel commencing to right itself.

(iii) *Floating the hull* from the dry dock in which she was built has many advantages, the chief of which is that she is placed in the water without subjecting her to stresses as severe as those imposed by launching in any other manner. Consequently, the time required between the completion of placing the concrete and floating the vessel is greatly reduced. The advantages of floating from a dock are :—

(*a*) The possibilities of failure of the hull during the process of launching are much reduced.

(*b*) Fewer berths are required to execute any programme in a given time, as there are less ships lying " weathering " on dry land.

(*c*) The ground can be permanently levelled and prepared so as to form the exterior surface of the bottom shuttering, thus reducing the outlay on wood or other shuttering.

The chief disadvantage of this method of placing the hull on the waterway is its cost.

An ingenious means of floating the hull without the use of a dry dock has been devised by N. K. Fougner (Eng. Pat. 2,138–1912) who builds the vessels in a steel framework or cradle (*Figs.* 166 *and* 167) mounted on wheels which run on a slightly sloping track. The cradle and vessel are launched simultaneously ; the cradle then sinks and the vessel floats away from it.

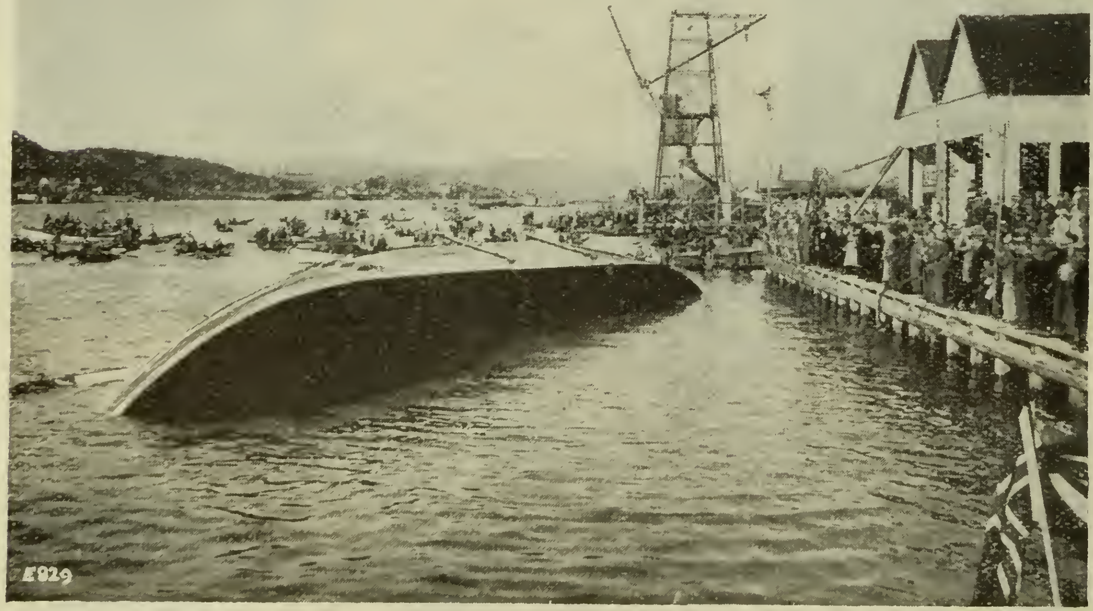


Fig. 164. Vessel half righted.

(iv) *Lifting and lowering* the hull by means of cranes or ropes is the method commonly adopted for placing lifeboats and other small vessels on the water, but it is regularly used successfully, on the Seine, near Paris, for towing boats of 300 h.p. These vessels, which are about 150 ft. in length, are fitted with two stirrups (*Fig.* 168) and lifted by means of a travelling crane fitted with two jibs, the weight of the vessel being balanced by a suitable counterpoise. For vessels of the size for which it is used this method appears to be quite satisfactory, but it could scarcely be applied to much larger ones.

The mode of launching which best suits the requirements of any one firm depends on the size and type of the concrete vessels constructed, the nature of the site and other considerations of a purely local character.

After launching, careful observation should be made to see whether the hull

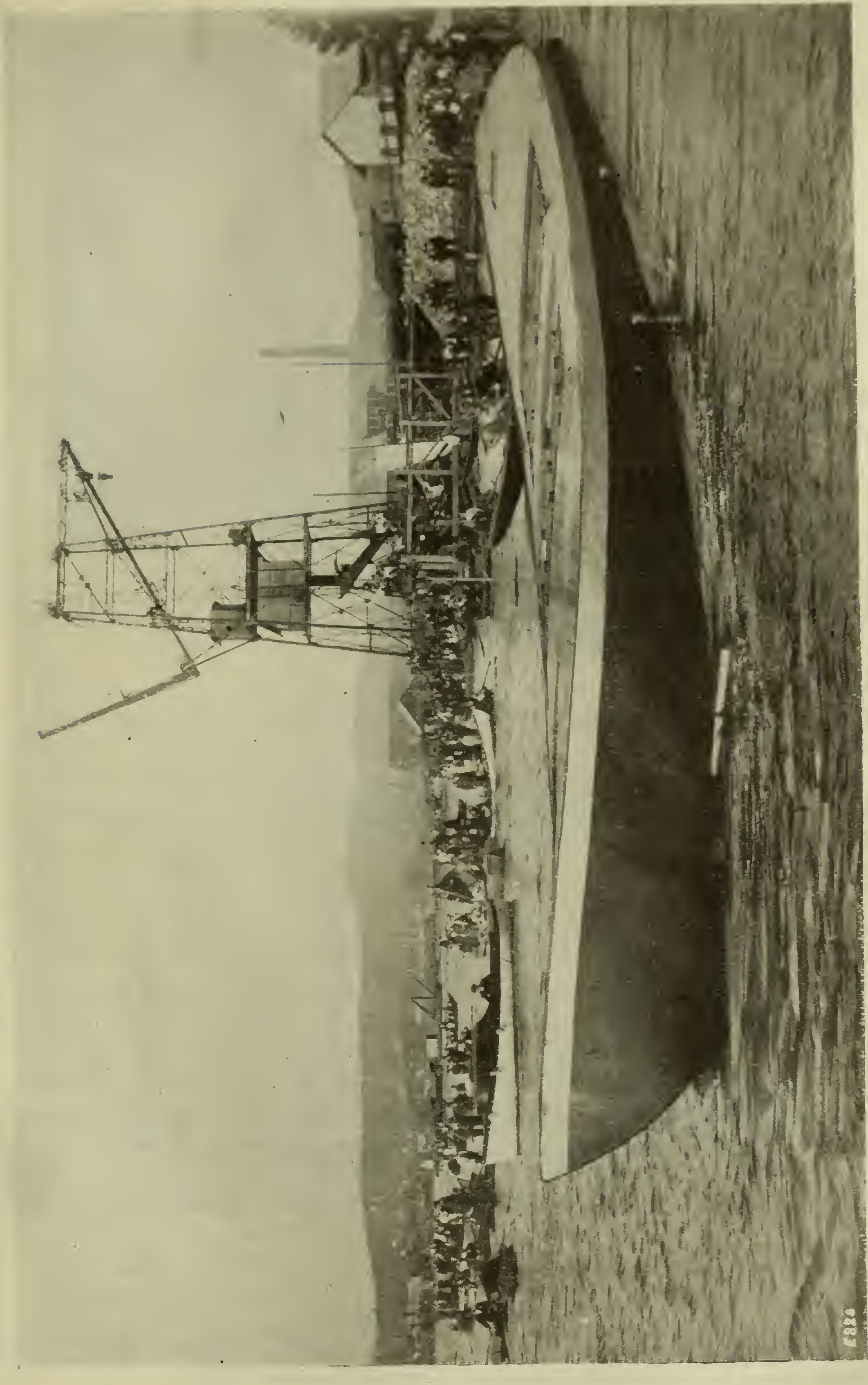


Fig. 165. Launching completed.

is watertight, and if a little water permeates through the shell water may be pumped into the hull to fill up the pores and interstices and also harden the concrete. As stated previously, after a small preliminary seepage a properly prepared concrete vessel will be quite watertight.

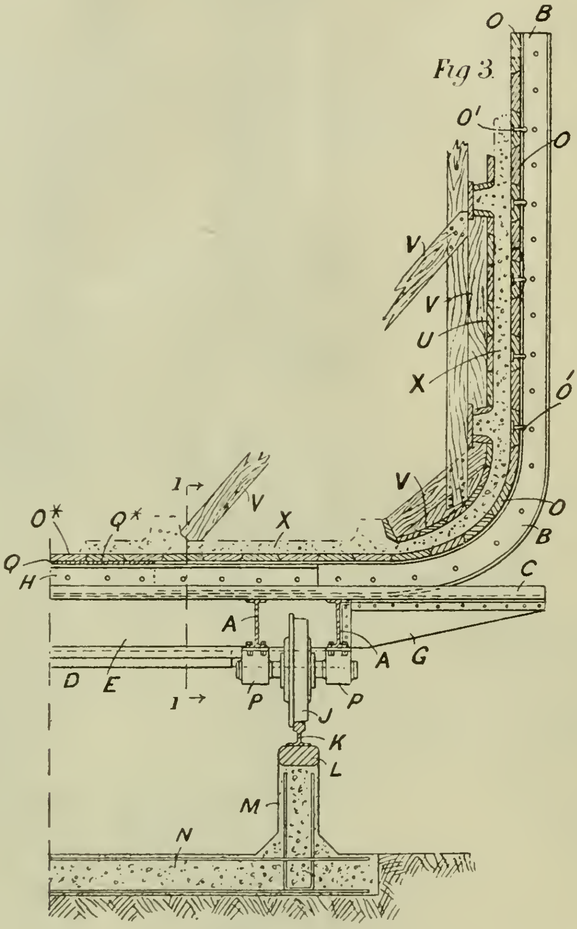


Fig. 166.

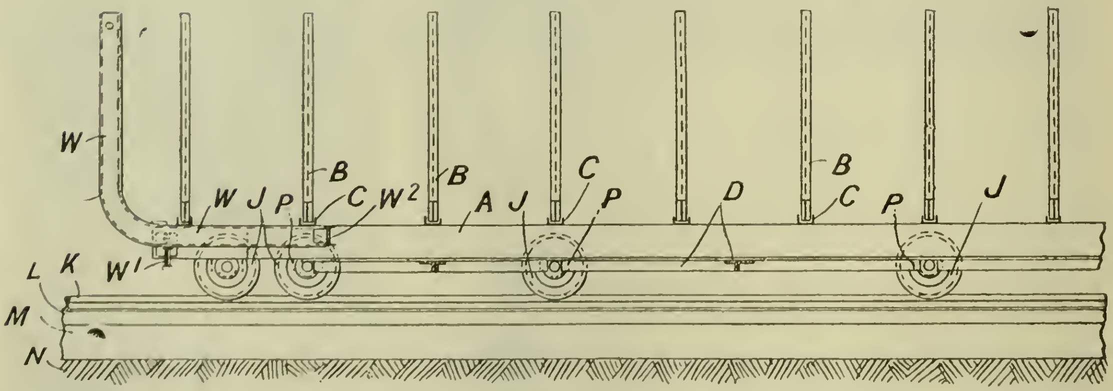


Fig. 167.

MEMORANDUM.

Just as we go to press we learn that the steamship *Faith* has made her first journey across the Atlantic and has arrived in the London Docks.

A CONCRETE VASE MODELLED IN CONCRETE BY MEANS OF TEMPLATES.

CONCRETE STONE MANUFACTURE.*

A Review.

By ALBERT LAKEMAN, M.S.A.

In view of the growing use of pre-cast concrete units, the following article, which is a review of a book recently published in America, may prove useful and of interest to those in this country who have given special attention to this form of concrete construction.—ED.

(*Concluded.*)

Natural Curing.—For proper development of strength under natural curing dry tamp and pressure products must be kept wet, must at no time be permitted to dry out, for a period of at least seven days. Sheds for natural curing should not admit direct sunlight on the products, must exclude draughts and must be at a temperature of at least 50° F. A warmer atmosphere gives even better results, yet the warmer the air the greater must be the watchfulness to see that the products do not become dry. It should be the special duty of at least one employee to see that the units are sprinkled with whatever frequency may be necessary, depending upon temperature conditions, so that the products will remain in a moist condition for the full period of seven days. If the weather is cold and the sheds inadequately heated this treatment should be prolonged. Moisture and heat are essential if concrete is to attain strength rapidly. Heat without moisture will give poor products.

Curing under Water.—In curing ornamental products some manufacturers make sure of supplying sufficient moisture by submerging the products in a tank of water. This is varied in other cases by filling urns, flower-boxes and similar products with water and covering them outside with wet cloths. When either of these methods is used products are covered with wet cloths for about 24 hours and are then either submerged in or filled with water.

Steam Curing.—Prevalent practice in steam curing is to use wet steam at a low pressure—to create a dense warm fog with all the moisture which can be introduced at a temperature in the curing rooms of a little above 100° F. The rooms should be long, low and narrow, for convenience in subjecting one lot of products to the treatment by means of simple pipe lines, without leaving a great deal of space open for the introduction of other products from time to time, and when they are built low the heat and moisture will not be wasted. The ceilings should be built so as to shed water to the sides and prevent condensed moisture from dripping on to the newly-made units. The arch form of roof is

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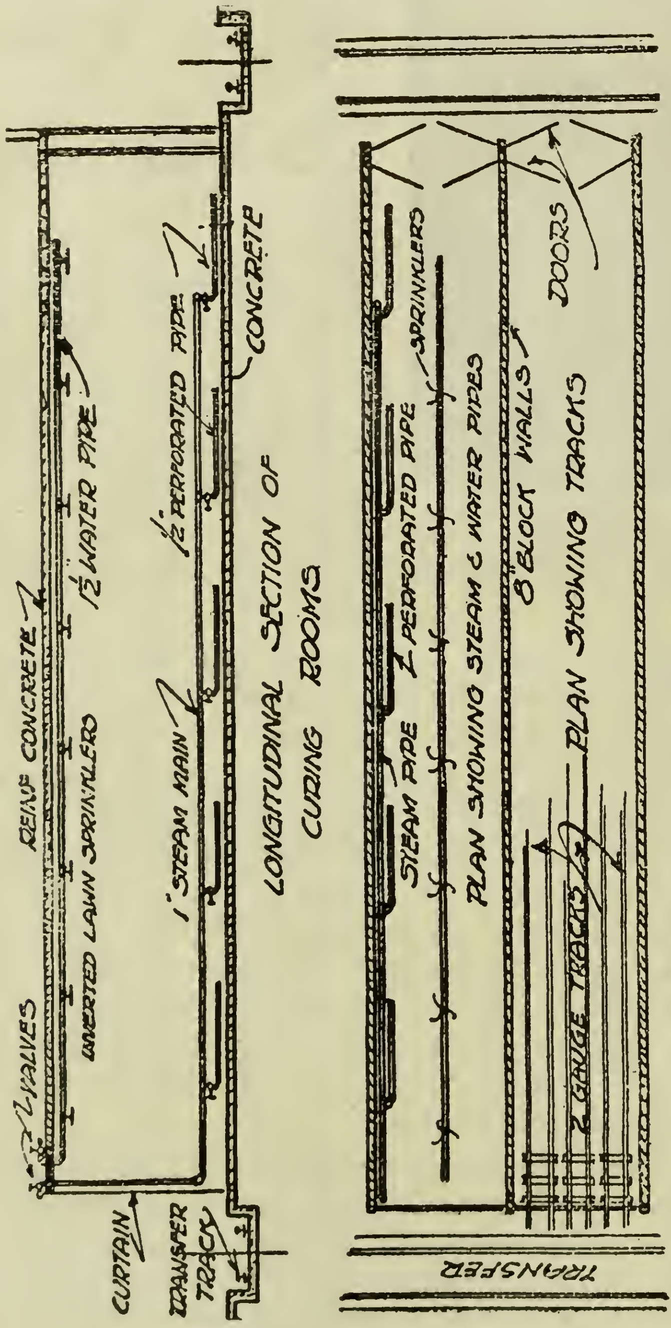
* *Concrete Stone Manufacture.* By Harvey Whipple.



Figs. 3 and 4. Longitudinal Section and Plan of Typical Curing Rooms.

most generally favoured and is readily constructed with metal fabric covered heavily on both sides with Portland cement plaster. The walls should be built with concrete, either monolithic or in the form of blocks. A plan and section of typical curing rooms are illustrated in *Figs.* 3 and 4, and the general arrangement of the steam pipes, etc., can be seen.

Special Moulds and Patterns.—A chapter is devoted to the consideration of this portion of the subject, and many useful hints and illustrations are given which indicate the very wide scope that exists for the manufacturer who sets out to produce special units having some architectural merit.

To be equipped to handle special work the manufacturer will step entirely outside the field of the so-called cement worker. His materials will include metal, wood, plaster, clay, gelatine, and sand, and he will require tne services of wood workers, plaster workers and modelers.

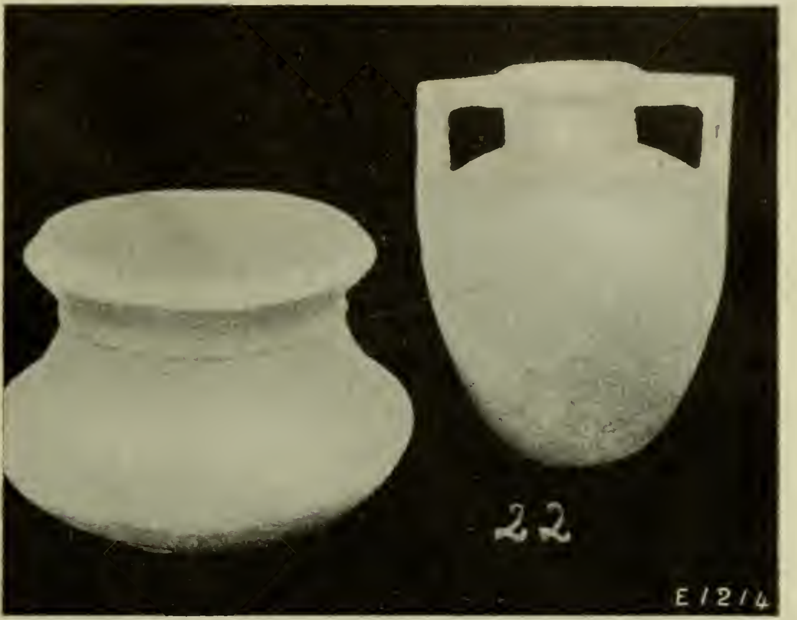


Fig. 5. Some Concrete Jars.

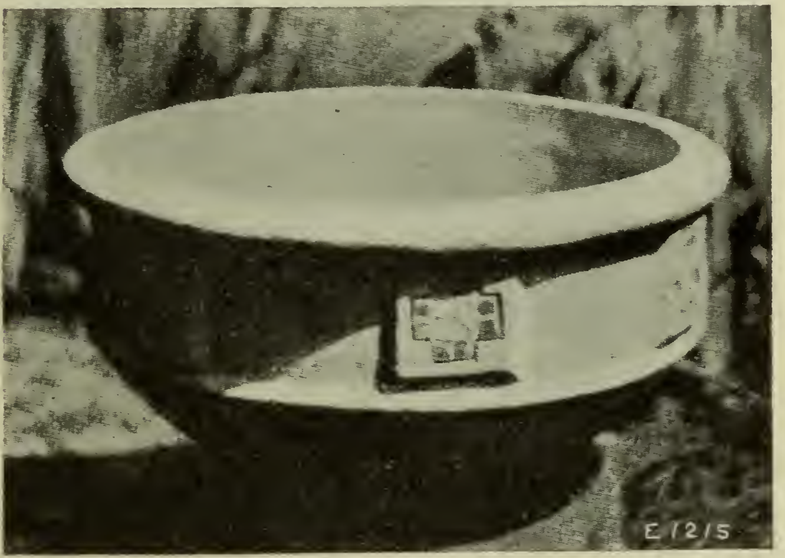


Fig. 6. A Concrete Flower Pot.

Usually, when there is deep and more or less intricate undercut in the design of the model, it is desirable to make the mould of gelatine so that it will pull away from the concrete casting without injury either to the fine lines of the concrete or the mould itself. If, however, the undercut is simple and the design not too complex it may be better to make the mould of plaster so divided into separate sections as to draw out of the undercut.

This is particularly true in making castings which are to have considerable duplication. Gelatine moulds can be used a few times only—sometimes four or five, sometimes, with special care, for a greater number of castings—yet the wet concrete attacks the glue and leaves it ragged, and when robbed of its fine lines the mould has to be melted and re-cast around the original model. For this reason it frequently happens, when a considerable number of like pieces are to be made, that there is economy in making a plaster mould, so divided and subdivided as to draw out of the undercut. With reasonable care a plaster mould is permanent and can be kept indefinitely, while a glue mould deteriorates with age and can seldom be used on later work.

If a model or design is very intricate or detailed and but few pieces are to be cast the cost of producing a model or mould or both, which will faithfully carry out the design, may be so great as to make it more economical merely to block out the detail and leave the fine lines of the design to be worked out by stone-cutters.

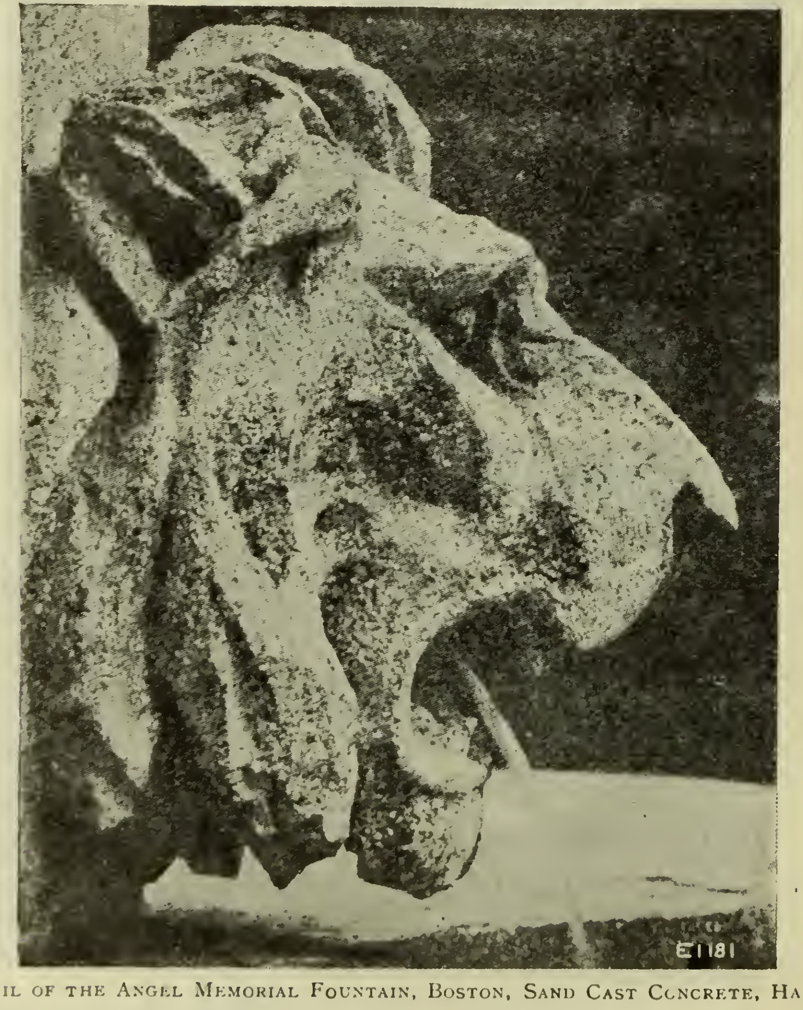


Fig. 7. Detail of the Angel Memorial Fountain, Boston, Sand Cast Concrete, Hand Tooled.

Moulds should be true to surface and form; wood used should be of the best and usually the mould parts should be carefully shellacked and oiled before casting. White pine is the most generally preferred material for wood moulds, although some stone manufacturers prefer cypress for its lasting and water-repellant quality. Others want all finished surfaces moulded or inserts of redwood, carefully sanded, shellacked and again sanded. Such fillers are used for as many as twenty casts before being smoothed and re-shellacked. Some examples of vases made of concrete are illustrated in *Figs.* 5 & 6, these being selected from the numerous photographs which are given in Mr. Whipple's book.

Surfaces.—The development of beauty in concrete building units is actually more deserving of serious consideration and painstaking effort than the development of strength, and the author truly states that the following faults are to be found in the ordinary concrete walling block :—

(1) They are of lifeless colour.
(2) The texture is monotonous and uninteresting.

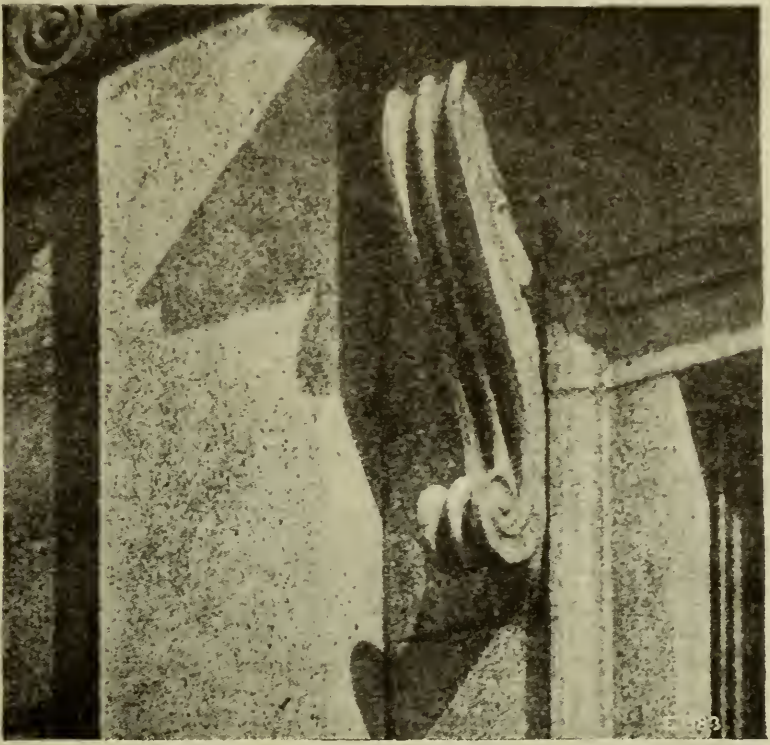


Fig. 8. Detail of a Mausoleum. (Rubbed Finish.)

(3) Commonly are of poor architectural design.
(4) Show moisture disagreeably after rain.
(5) Very frequently are poorly set and show ragged arrises.

Many of these faults can be overcome with proper care in the manufacture of the units, but too often the products are made without any special effort to produce a pleasing appearance and thus a bad reputation has been acquired which prevents the use of the material for artistic work. The author gives some very useful information on the best methods of obtaining good texture and colour, and several illustrations of artistic work are given to emphasise the possibilities of concrete when properly treated and applied. Two of these illustrations are reproduced in *Figs.* 7 & 8, and they will serve as examples of concrete units well executed.

The volume, generally speaking, contains much of interest and value and it is well worthy of study by those who are engaged in the manufacture of concrete units, as a wide market exists for such products, provided the articles offered to architects and other users are of good quality and possessed of merits which will commend them to such users.

HISTORY AND PROPERTIES OF LIGHT-WEIGHT AGGREGATES.

The following article, reproduced from "Engineering News Record," gives an account of some tests undertaken with light-weight aggregates for concrete for the building of concrete ships. The tests were undertaken under the direction of Mr. Rudolf J. Wig, of the Emergency Fleet Corporation, U.S.A., with the assistance of Mr. C. W. Boynton and D. W. Richardson.—ED.

Light-weight aggregate made from an artificially burnt shale or clay is now being used for the concrete on the Government concrete ships built in the United States. The concrete so made, in rich mixtures and with a fine-ground cement, weighs from 100 to 118 lb. per cu. ft., and tests in compression from 3,500 to 5,500 lb. per sq. in. at the end of 28 days. Furthermore, it is impermeable, readily workable, and, so far as has been ascertained, has no defects not common to concrete with any of the more generally used aggregates. This artificial aggregate has been developed by the concrete ship section of the United States Emergency Fleet Corporation, but until now no definite statement of its method of manufacture or of its properties has been given out.

Early in the study of the concrete ship it became evident that to compete commercially with wood and steel the concrete must be lighter than the 150 lb. per cu. ft. of the structural mixture commonly used. Naturally, low-weight concrete meant a low-weight aggregate. Many investigations were made into the possibilities of slag and various light, natural aggregates, such as volcanic scoria, pumice, etc., all of which are of a vesicular nature—that is, full of small non-connecting cells which reduce weight. In pursuance of these studies it was found that certain clays or shales could be burnt so as to produce a light-weight vesicular product similar in appearance and qualities to the volcanic basalts, but more uniform in character and therefore better fitted for aggregates.

Accordingly, experimental work was started at the Bureau of Standards in the early summer of 1918 on quantity production of this material. The first working plant was a down-draught beehive kiln near Birmingham, Ala., where enough aggregate was turned out to supply the 3,000-ton *Atlantus*, launched in December at Brunswick, Ga. Experiments were also carried on in a portland cement rotary kiln at Ragland, Ala., and initiated at a railroad tunnel kiln at Perth Amboy, N.J., local clays and shales being used at each, but neither progressed beyond the experimental stage. Later, however, two contracts were let for quantity production for the big concrete ships under way; one to the Atlas Portland Cement Co., which makes the aggregate in cement kilns at Hannibal, Mo., and one to the Los Angeles Pressed Brick Co., which made the aggregate in dome kilns formerly used for burning brick. Both plants are now producing aggregates, the Hannibal plant supplying the ships at Wilmington, N.C., Jacksonville, Fla., and Mobile, Ala., and the Los Angeles kilns those at San Diego and San Francisco. In all, 25,000 tons of the aggregate will be required for the present Government programme.

The new light-weight aggregate, as has been stated, is an artificially burned clay or shale uniformly filled with small non-connecting cells. Speaking non-technically, it is a bloated brick—that is, the basic clay or shale from which it is formed, when subjected to a temperature of about 1,800 deg. to 2,000 deg. in a kiln, becomes plastic and sears over on the surface, a coating being formed there which retains the gases generated by the decomposition, under heat, of the contained compounds. This expanding gas blows the brick or the clay ball full of holes and bloats it to several times its original size.

Various clays and shales are of the proper quality and consistency for such an aggregate. The material from which the aggregate is made should be rich in compounds of metallic oxides, carbon, sulphur, sodium, potassium or other equivalent compounds, some of which, when the material is subjected to heat, will either act as a flux in reducing the more refractory compounds or will give off gas at the desired time, or both. The use of clay or shale containing a relatively high percentage of calcium carbonate or magnesium carbonate should be avoided, as such undesirable elements, after being subjected to a temperature sufficiently high to change their form, would be detrimental to the product. The ratio of the fluxing constituents to the non-fluxing constituents can vary within wide limits, but ratios indicating fusibility at comparatively low temperatures may be commercially preferable.

Such material is widely distributed, having been found in Alabama, New Jersey, Missouri, New York and California, and used commercially in the production of aggregates in those localities. An analysis of a typical clay or shale of which such aggregate is made is as follows :—

	Per Cent.		Per Cent.
S_1O_2	60	SO_3	1
Fe_1O_3	8	CO_2	2
Al_2O_3	19	Alkalis	3
CaO	1	Water	·5
M_gO	1		
		Total	100

Such composition is found both in shales and clays. Both can be used in the manufacture of the aggregate, although the process of manufacture is slightly different. Either one weighs about 100 lb. per cubic foot in its natural state.

In general, in the production of the aggregate the raw shale or clay must first be reduced by means of suitable crushers or disintegrators to a fineness so that all of if will pass through about $\frac{3}{16}$-in. openings. The purpose of this reduction is to obtain uniform texture and to prevent striations or laminations which might otherwise result in the finished material. It is then burned in a kiln, according to either the wet or dry process as noted hereinafter, is taken from the kiln either in large balls or in the bloated brick, and is then crushed to the required sizes for the aggregate, which, in the concrete-ship work, is not larger than passing through a $\frac{1}{2}$-in. round opening.

The aggregate burned in the stationary brick kilns is prepared as an ordinary brick for the burning. Such a product used on the Brunswick ship was made at the brick plant of the Copeland-Ingles Shale Brick Co. at Alton, near Birmingham, Ala. This material was burned in an ordinary type of down-draft dome brick kiln. The raw material, which was a shale, was prepared as for common, stiff-mud brick, and after drying to a less degree than is the practice for the production of common brick, was placed in the kiln, set rather close in columns, leaving space for swelling, and fired rapidly. The resulting product was more or less oxidised on the surface, and lacked the uniformity possible by other methods of burning. However, most of the product was quite satisfactory. The bricks, when sufficiently cool, were taken from the kiln, crushed and screened. The coarse aggregate was that which passed the $\frac{1}{2}$-in. screen and was retained on the $\frac{3}{16}$, the fine aggregate that passing the $\frac{1}{16}$-in. screen to dust. The tests of the concrete made from this aggregate are given in Table III. Local coal was used for the fuel in the kilns.

While burning the aggregate at Alton, experiments were also made in burning the same material in a rotary kiln at the plant of the Coosa Portland Cement Co. at Ragland, Ala. In the experiments the shale from Alton and the shale from the cement company's land were both used. There was practically no difference in the products of the two materials, neither was there much difference in the analysis of the shales. In this experiment the shale was prepared by passing it through Fuller mills and then directly to the kiln in the form of both a dry powder and a slurry. Bricks, also, were made at Alton and shipped to be burned in the rotary kiln, with quite satisfactory results. From the experiment, though it was not extensive enough to establish the fact, it would seem that somewhat better results might be expected from the use of a slurry than from the use of a dry feed. Some very excellent material was produced during this experiment, made in an ordinary cement kiln, 8 ft. in diameter by 125 ft. long, using powdered coal as fuel. None of this material was used in the ships.

TABLE I. COMPRESSION TESTS OF LIGHT-WEIGHT AGGREGATE CONCRETE MADE AT HANNIBAL, MO.

Tests made on 6 by 12 inch cylinders at mill. Mixture = 1 part Atlas Portland cement, ⅔ part fine aggregate, 1 part coarse aggregate.

Typical sieve analysis :—Fine aggregate : Per cent. passing sieves No.

10	20	40	60	80	100
90·0	70·0	44·3	29·1	18·1	12·1

Coarse aggregate : Per cent. passing screens :

$\frac{5}{32}$ in.	½ in.	⅝ in.
5·0	78·0	100·0

Fine Aggregate Wt. Lb. per Cu. Ft.	Coarse Aggregate Wt. Lb. per Cu. Ft.	Water, per cent.	Consistency Drop, Inches.	Compressive Strength in Lb. per Sq. In. One Week. Age.	Strength.	One Month. Age.	Strength.	Wt. of Concrete Green Lb. per Cu. Ft.
70·1	41·8	22·6	8	7	2510	28	4303	115·0
68·0	42·0	21·9	9	7	2584	28	4199	115·5
76·0	44·0	21·5	8	8	2545	28	3554	115·0
74·0	46·0	22·0	8	7	2428	28	3751	116·5
74·0	47·0	20·9	7	8	2313	28	4173	116·0
72 0	47·0	21·1	9	7	2313	28	3806	117·5
69·0	42·0	22·2	9	7	1793	28	3246	115·5
73·0	44·0	22·3	9½	10	2062	28	3236	117·7
72 0	42·0	22·0	9	—	1863	28	3567	116·0
72·0	43·5	21·9	9	—	1766	30	3703	115·0
68 0	43·0	20·6	7	11	2552	28	4718	114·0
68·6	45·0	19·3	7½	—	2485	28	5059	114·5
63·0	42·0	22·2	9	11	3192	30	3920	114·0
66·5	43 2	22·2	9½	9	2910	28	3852	114·0
67 0	43·0	21·2	8	10	3117	28	4495	114·5
68·0	43·0	21·5	7	7	2370	28	4252	112·6
71·0	44·0	20·7	7	7	2941	28	4664	114·0
71·0	44·0	20·5	9	7	3074	28	5128	114·5
70·0	45·0	20·4	8	7	2844	28	4982	116·0
71·0	43·5	22·0	8	7	2529	28	4055	114·0
70.0	45·0	21·2	9	9	2893	28	4333	117·0
70·0	44·0	21·4	8	7	2473	28	3735	116·0
68·0	44·0	21·0	8	7	2532	28	4732	114·0
64·0	40·0	21·0	7½	7	2678	28	4808	112·0
64·0	38·0	22·0	8½	7	2125	28	4112	112·0
68·0	41·0	22·2	8	8	2360	28	3669	114·0
68·0	45·0	22·0	8½	9	2394	28	4299	112·6
73·0	45·0	22·0	9	7	2415	28	4370	115·3
72·0	46·0	22·0	8½	7	2415	28	5397	115·8
71·0	46·0	22·0	8	7	2783	28	4703	116·5
70·0	45·0	22·0	9½	8	2959	28	5358	115·0
69·0	44·0	22·7	10	8	2761	28	5096	114·0
70·0	44·0	22·0	9	8	2694	28	4104	114·2
70·0	44·0	22·0	9	9	2970	28	4344	114·5
69·0	44·0	23·0	9	7	2431	28	4562	114·0
70·0	50·0	22 8	9	7	2491	28	4561	114·2
71·0	45·0	22·0	8½	7	2780	28	4857	116·0
71·0	44·0	22·1	9	7	2429	28	4531	114·4
68·0	43·0	22·0	9	7	2605	28	4587	114·0
70·5	46·0	22·1	9	7	2557	28	4858	114·2
69·0	43·0	22·0	8½	7	2332	28	4602	114·0
67·0	42·0	22·0	8	7	2617	28	5049	114·0
67·0	42·0	22·0	8	7	2617	28	5049	114·0
67·0	43·0	22·7	9½	7	2423	28	4742	113·5
67·0	43·0	22·4	9	8	2848	28	4194	112·7
68·7	43·5	22·0	8	8	2772	28	4528	112·6
68·0	44·0	22·2	9	7	2374	28	4972	113·1
72·0	44·0	22·0	8½	9	2454	28	3897	113·9
69·0	43·5	22·0	9	7	2439	28	4510	—
67·6	42·5	22·0	9	8	2840	28	4601	112·1
70·2	45·5	22·5	8	7	2638	28	4378	114·0
76·0	45·0	23·5	9	7	2288	28	4489	113·2
74·0	45·3	22·9	9	7	2325	28	4179	112·8
68·0	46·0	22·0	8	9	2758	28	5141	112·8
70·0	45·0	22·0	8½	7	2407	28	5061	114·0
68·0	43·0	22·9	9	7	2284	28	4596	112·5
70·0	43·0	23·0	8½	7	2517	28	4233	112·7
68·0	42·0	22·5	9	7	2257	28	4729	113·0
68·0	43·0	22·6	9	8	2316	28	4964	112·8
68·0	42·0	21·8	10	7	1916	28	4048	112·6
72·0	43·0	23·0	9½	8	2186	28	4271	112·5
70·0	41·0	24·0	10	7	2173	28	4529	113·0
Average …	…	…	…	…	…	…	4417	114·2

TABLE II. COMPRESSION TESTS ON LIGHT-WEIGHT AGGREGATE MADE AT HANNIBAL, MO.

Tests made on 6 by 12 inch cylinders poured with ship at yard.
Portland cement passing 90 per cent. through 200-mesh sieve.
Consistency drop averages 9 inches.

Yard and Ship:	Age. Days.	No. of Cylinders.	Mixture.	Weight per Cu. Ft.	Compressive Str., Lb. per Sq. In.	Modulus of Elast.
Wilmington, 1562	28	9	1 : 1 : 1	118·5	4744	3,030,000
Wilmington, 1560	28	11	1 : 1 : 1	116·0	5169	3,105,000
Mobile, 1716	28	18	1 : 1 : 1	118·9	559	3,306,000
Mobile, 1715	28	20	1 : 1 : 1	117·1	5157	2,997,000
Jacksonville	7	3*	1 : 1 : 1	116·0	5158	—

* Tests on cubes.

Further experiments were made at certain other places, both with tunnel kilns and with ordinary brick kilns, but none of the material was used in practical work.

Later a contract was entered into with the Atlas Portland Cement Co. to produce light aggregates in its plant at Hannibal, Mo., using shale found on the property. The raw material here was reduced to a fineness of approximately 100 per cent., through a 50-mesh screen, and introduced into a large cement rotary kiln in a dry state, with powdered coal as fuel. This burned ball coming through the rotary was passed directly into a crusher while hot and sorted at the distribution end of the kiln. Crushing the material while hot and malleable produced particles of a spheroid shape with few of the sharp corners which distinguish the cold-crushed material. In this product there is a rather large quantity of extra hard, burned small particles, which are screened out before the larger particles are crushed. These hard fines weigh considerably more than the more porous product, but on account of the expense of production they are being used in the ship work. As noted in the tables and descriptions farther on, they tend to increase the weight of the concrete a few pounds over that of the concrete made from the brick aggregate.

Still later an agreement was made with the Los Angeles Pressed Brick Co. to produce the aggregate in semi-muffle and down-draft kilns, using oil as fuel. In this plant the material is pugged and mixed with water and forced through brick machines and burned as ordinary brick. There is being produced here a remarkably light and satisfactorily strong material, as shown in the data in Table IV. It is being used on the San Diego and San Francisco ships.

The aggregate as used in the concrete ships is as a rule being divided into two sizes, the coarse material, that which passes through a screen having $\frac{1}{2}$-in. round openings and is retained on the screen having $\frac{1}{2}$-in. round openings, and the fine material, that which passes through a screen having $\frac{3}{16}$-in. round openings. In the ships the concrete is mixed in the proportions of one part cement, two-thirds part fine aggregate, and one and one-third parts coarse aggregate, although in some of the yards these proportions have been changed to slightly different mixtures which are noticed in the various strength tests given herewith. The early specification for the concrete was that the 1 : $\frac{2}{3}$: $\frac{4}{3}$ mixture with sufficient water to produce a consistency drop of 9 in. shall develop in seven days a minimum strength of 2,500 lb., using standard American portland cement. In the ship the special fine-ground cement, passing 90 per cent. through the 200-mesh screen, is being used. The tests, as given in the accompanying tables, indicate that the 2,500 lb. would be a safe minimum for the seven-day test, with 4,000 or even 4,500 lb. per sq. ft. for the 28-day test. The early specifications for the weight of the aggregate were that the coarse material should not weigh more than 37 lb. per cu. ft. This is somewhat lighter than the average material produced.

Tests are given in the various tables herewith. Table I. represents the mill test of the concrete aggregate made at Hannibal, mixed to a 1 : $\frac{2}{3}$: 1 proportion. These are compression tests on 6 × 12-in. cylinders and represent material shipped to Mobile, Jacksonville and Wilmington. The screen analysis of only one of the aggregates is given, but this is fairly representative of the group. From this it will be seen that the fine aggregate made at Hannibal averages about 67 lb. per cu. ft. in weight and the coarse aggregate about 43 lb. per cu. ft., that the seven-day compressive strength is about 2,500 lb. per cu. ft., the 28-day compressive strength averages 4,417 for 61 tests, and that the weight of the concrete for the same number of tests is 114·2 lb. per cu. ft. The low compression for 28 days is 3,246, and the high 5,397, with only two testing below 3,500 and eight above 5,000. The low weight for the wet concrete is 112 lb., and the high 117$\frac{1}{2}$ lb.

Table II. gives the result of cylinders taken from the actual pourings of the various Atlantic and Gulf ships of concrete made with the Hannibal aggregate. From these it will be seen that the 28-day test of a 1 : 1 : 1 concrete made up of the aggregates of the sizes noted before averages well above 5,000 lb. per sq. in., and that the weight is somewhat higher than the weight of the mill-tested concrete of the 1 : $\frac{2}{3}$: $\frac{4}{3}$ mixture, running around 116 lb. per cu. ft. This, however, is the weight

TABLE III. COMPRESSION TESTS ON LIGHT-WEIGHT AGGREGATE MADE AT ALTON, ALA.

Tests on 6 by 12 inch cylinders poured with ship at yard.
Portland cement passing 90 per cent. through 200-mesh sieve.
Consistency drop averages $8\frac{1}{2}$ inches.

Mix.	Age.	No. of Spec.	Wgt. Lb. Cu. Ft.	Compression, Lb. Sq. In.	Modulus of Elast. at 1500 Lb. Sq. In.
1 : $\frac{2}{3}$: $\frac{4}{3}$	1 mo.	2	115·7	3042	2,866,000
1 : $\frac{2}{3}$: $\frac{4}{3}$	$1\frac{1}{4}$ mo.	14	114·2	3774	2,608,000
1 : $\frac{2}{3}$: $\frac{4}{3}$	60 days	14	111·6	3836	2,398,000
1 : 2	1 mo.	2	128·1	4375	3,080,000
1 : 2	$1\frac{1}{4}$ mo.	5	122·0	3740	2,608,000
1 : 2	60 days	15	121·0	4493	2,733,000
1 : 1	1 mo.	3	124·3	4055	2,720,000
1 : 1	60 days	2	125·2	6195	2,355,000
1 : $\frac{2}{3}$: $\frac{4}{3}$	59 days	4	112·0	4425	—
1 : $\frac{2}{3}$: $\frac{4}{3}$	35 days	3	124·0	4280	—

TABLE IV. COMPRESSION TESTS OF LIGHT-WEIGHT AGGREGATE MADE AT LOS ANGELES, CALIFORNIA.

Tests made on 6 by 12 inch cylinders mixed by hand for the test. Mixture 1 part Portland cement ground to pass 90 per cent. through 200-mesh sieve, $\frac{2}{3}$ part fine aggregate, $\frac{4}{3}$ part coarse aggregate. Typical sieve analysis :—

Fine aggregate. Per cent. passing Sieve No.

10	20	30	40	50	80	100	200
93·4	74·2	64·0	57·4	54·6	40·4	35·4	25·4

Coarse aggregate. Per cent. passing sieve :

$\frac{3}{8}$-in.	$\frac{1}{4}$-in.	$\frac{1}{10}$-in.
98·4	80·4	4·6

Fine Aggregate Wt. Lb. per Cu. Ft.	Coarse Aggregate Wt. Lb. per Cu. Ft.	Consistency Drop in inches.	Water, per Cent.	Compressive Strength, Lb. per Square Inch. 7 Days.	28 Days.	Wt. per Cubic Ft. in Lb. Green.	7 Days.	28 Days.	Yield per Cent.
61·5	41·5	9	20·4	2563	3676	111·0	106·5	107·5	147·0
61·0	41·0	$9\frac{1}{4}$	23·8	2765	—	112·0	108·2	—	151·0
57·5	37·2	$9\frac{1}{4}$	22·7	3035	—	113·5	108·2	—	143·2
61·3	37·5	9	22·4	2641	—	113·0	106·2	—	149·5
60·3	39·7	$8\frac{7}{8}$	21·4	2816	—	113·0	109·5	—	145·5
58·8	38·8	$9\frac{1}{8}$	22·6	2682	—	111·5	107·3	—	145·5
62·8	46·0	$9\frac{1}{8}$	17·7	2890	—	109·5	108·7	—	150·1
57·5	42·5	9	20·9	2794	—	107·5	107·2	—	150·5
61·3	40·0	9	23·5	2480	—	113·5	108·5	—	147·5
60·0	42·8	$9\frac{1}{4}$	21·3	2861	—	112·0	108·7	—	145·5
62·8	45·6	$9\frac{1}{8}$	23·1	3015	—	116·0	109·0	—	154·5
69·0	44·3	$9\frac{1}{4}$	22·8	2639	—	114·5	109·6	—	158·6
63·0	41·5	9	22·3	2575	—	112·0	—	—	145·5
61·7	38·0	9	21·1	3652	—	113·0	108·6	—	145·5
66·6	39·0	$9\frac{1}{8}$	23·6	3216	—	113·0	109·6	—	145·5
64·0	39·5	9	23·8	3315	—	113·5	109·1	—	145·5
55·6	38·0	$9\frac{1}{4}$	23·6	—	—	111·0	—	—	143·3
56·8	39·0	9	21·1	—	—	111·0	—	—	150·6
58·4	40·3	9	23·2	—	—	110·5	—	—	145·1
Average ...	...	...	...	2867	—	112·1	108·3	—	—

NOTES.—The per cent. of water is based on the weight of dry material, including cement and aggregates.

The yield as used is the volume of concrete divided by volume of coarse aggregate.

Aggregates were wet when made into concrete.

TABLE V. COMPRESSIVE TESTS OF LIGHT-WEIGHT CONCRETE USED IN CONSTRUCTION OF HULL 1662, SAN FRANCISCO SHIPBUILDING COMPANY.

Mix :—1 part reground cement.
⅔ part fine aggregate ($\frac{1}{10}$ in. down).
1⅓ part coarse aggregate (½ in.—$\frac{1}{10}$ in.).

Consistency Drop. In.	Age Days.	Compressive Strength Lb. per Square Inch.	Weight per Cub. Ft., Lb.
8⅞	7	3040	104·2
9⅛	7	2677	107·5
9	7	2872	105·9
9⅛	7	2637	104·1
9⅝	7	2681	107·6
9¼	7	2751	109·3
9¾	7	3393	104·9
9⅜	7	3447	108·4

Last four mixes have 1 ½ per cent. diatomaceous earth by weight of cement, added to overcome the tendency of the concrete to segregate.

immediately after pouring, and other tests have shown that this decreases 3 or 4 lb. in the 28-day test. Table III. shows the tests of various proportions and various ages of the dome-kiln aggregate used in the *Atlantus* at Brunswick, Ga. The strengths are not quite as high as the others given, but the weights are about the same. Tables IV. and V. give the results of some of the tests of the Pacific Coast aggregates. In experimental mixtures not noted here the material dropped as low as 92 lb. per cu. ft. in weight and averaged below 100 lb. Tests on the concrete as poured in the ships show that while the weight is not quite so low it is somewhat less than with the Eastern aggregates and the strength is satisfactory.

There has not been sufficient time to make long-time tests of the light-weight concrete, but a few such tests, noted in Table VI., show values as high as 7,200 lb. at 3 months, and for the standard consistency of the other tests a strength of 6,483 lb. for the same period.

Some concern is occasionally expressed as to the permeability of a concrete made with this material. A number of tests have been made, and they all show that such a concrete is as low in absorption and in permeability as concrete made with an apparently more dense aggregate. The material is not porous. While full of holes, it must be remembered that they are nonconnecting holes, so that there is no reason why water should pass through such a concrete, assuming that the aggregate itself is of a dense material. Very few strength tests on the aggregate itself have been made. Recent tests at the University of Pennsylvania laboratory show that in 1-in. cubes it has an average compressive strength of about 1,500 lb. per sq. in., with values in test ranging from 1,000 to 2,500 lb.

TABLE VI. THREE-MONTHS' COMPRESSION TESTS OF LIGHT-WEIGHT CONCRETE.

Commercial cement with a variation of workable consistencies. Mix = 1 : ⅔ : $\frac{4}{3}$.

Consistency Drop, In.	Compressive Strength. Lb. per square inch.
5½	7285
7	6560
9	6483
10½	6180

Commercial production of the aggregate except for the Government ships has not been started, though there are prospects that one or both of the Government contractors will continue production after the ship requirements are satisfied. There is a company in Kansas City which is manufacturing a somewhat similar product known as Haydite. This material was used in the concrete superstructure of the freight car recently exhibited in Chicago.

The technique of the manufacture of the aggregate is necessarily complicated, as the value of the resulting product depends so much on the quality and moisture content of the raw material, the nature of the preliminary treatment, the degree of heat, and many other details. There is no claim that perfection has been reached in the brief time in which experiments and quantity production have been under way, but the aggregate is uniform and satisfactory in quality and there is every hope that its commercial manufacture is possible.

CONCRETE DEFENCES IN THE HINDENBURG LINE.

Some interesting particulars have been published in the "Professional Memoirs, Corps of Engineers, U.S.A.," regarding the concrete defences in the German lines known as the Hindenburg Line. The report is by Mr. G. B. Pillsbury, Deputy-Chief Engineer, American Expeditionary Force.—ED.

THE particular section described here was that assigned to the 2nd Army Corps of the American Expeditionary Force in the attack on the Hindenburg Line, September 29th, 1918, and embraced a front of 6,000 yd. To the north and south of the sector the defence rested on the line of the St. Quentin Canal, but in the sector itself the canal passed through a deep tunnel from 100 ft. to 200 ft. underground, thus necessitating no defence of this unit. The land is characterised by rolling hills of some elevation, but with gentle slopes, and is bare of trees. The line itself runs through the small village of Bony and in front of Bellicourt, but both of these places were reduced by artillery fire.

The Hindenburg Line on this front was deliberately prepared for resistance. It is more of the nature of a semi-permanent line of fortifications rather than field works. In all of the works constructed by opposing forces during the long years of trench warfare, this line of defence stands out as the most elaborate and thorough. In this sector it consists of 2 to 3 lines of trenches provided with underground dug-outs and concrete shelters, machine-gun emplacements and observation posts.

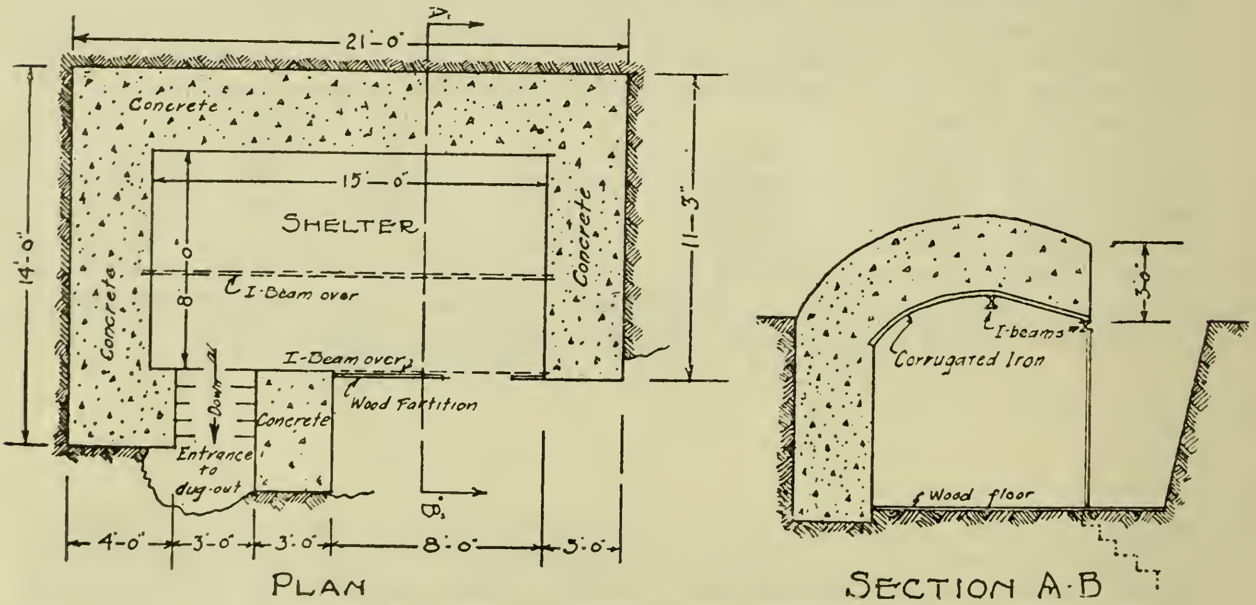


Fig. 1. Concrete Shelter at entrance to a dugout.

The trenches alone, however, are not unlike those used by both armies on the various fronts. Shelters were of three classes: light shelters under the parapet, cave shelters (mined dug-outs), and concrete shelters.

Light shelters were found only in the advanced line in front of Bellicourt, while cave shelters were plentifully provided in the trenches proper and in the front lines, except near Bellicourt, and also in the rear lines. There were at least 50 of these, with 100 gallery entrances to them, per mile of front. In a few cases the entrance galleries to the cave shelters and also the approaches were constructed of concrete, as shown in *Figs.* 1 and 2.

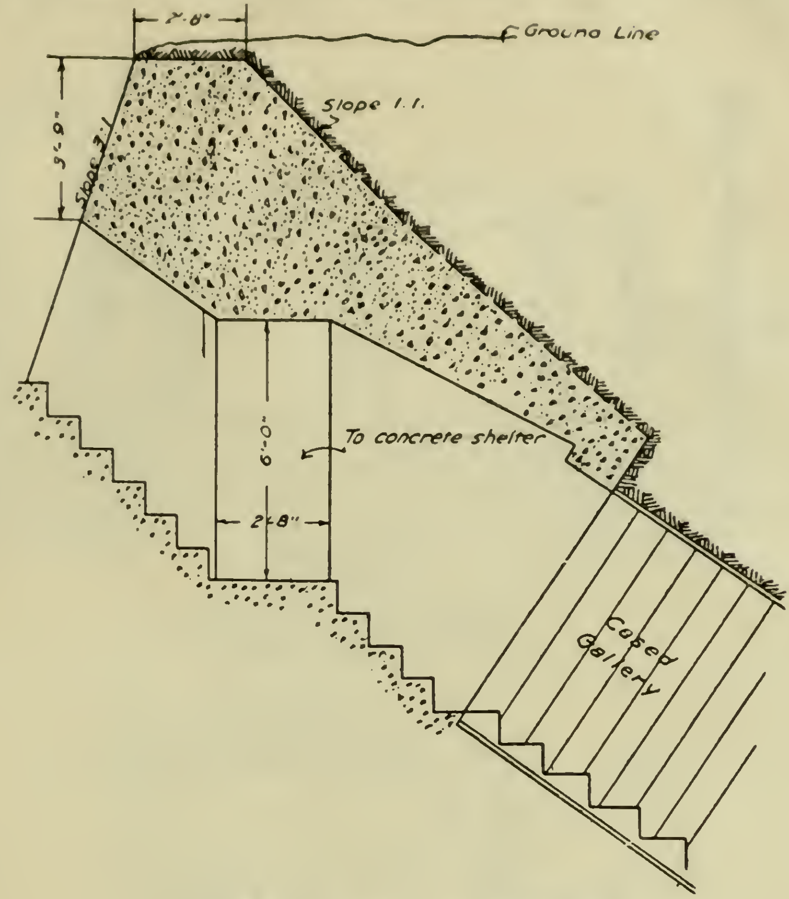


Fig. 2. Massive concrete entrance to a dugout.

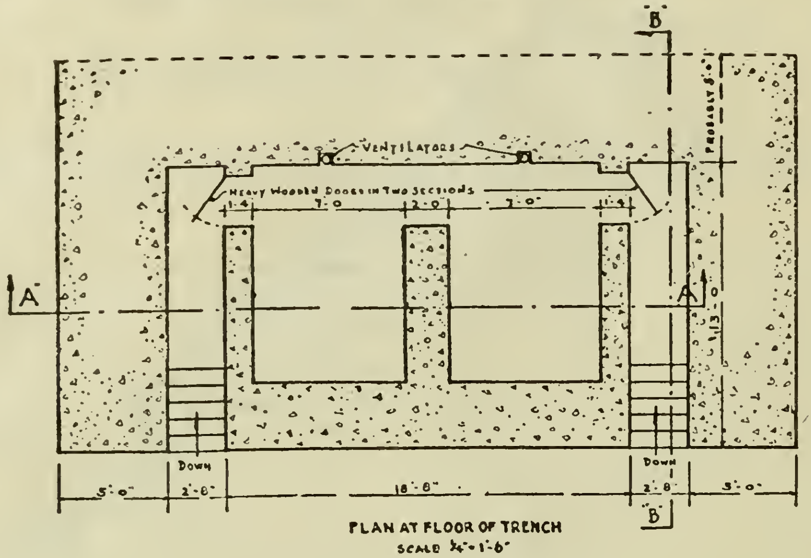
CONCRETE SHELTERS.

Shelters of reinforced concrete were fairly numerous. They were placed at salients and near the roads, generally in the front line, but occasionally in the rear lines, with occasional concrete shelters for machine-gun crews in front or in rear of the trenches, and for command posts in rear. Altogether, 34 of these shelters were counted on the 6,000 yd. front, but there are probably quite a few more detached ones that were not discovered.

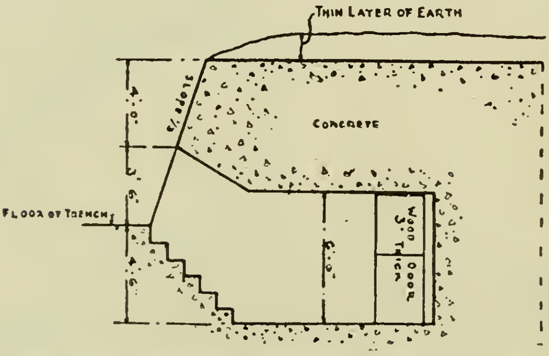
The concrete shelters were of various designs. The predominant type of those placed in the trenches is shown in *Fig.* 3. These were located in the fire-bays, the rear wall flush with the interior slope of the trench and having the same batter. The thickness of the frontal protection was not measured, but is probably 5 ft. The thickness of the floor is likewise not certainly known. A drain in one of the shelters showed 3 ft. of concrete. It is possible the drain may have been boxed with concrete, but it seems likely that this represents the thickness of the floor.

In all cases provision was made for a fire-step along the rear face of shelters of this type in continuation of the normal fire-step of the trench. In a few cases the step was moulded of concrete, but usually provision was made for a wooden step in the form of a plank supported by brackets of strap-iron set in the concrete.

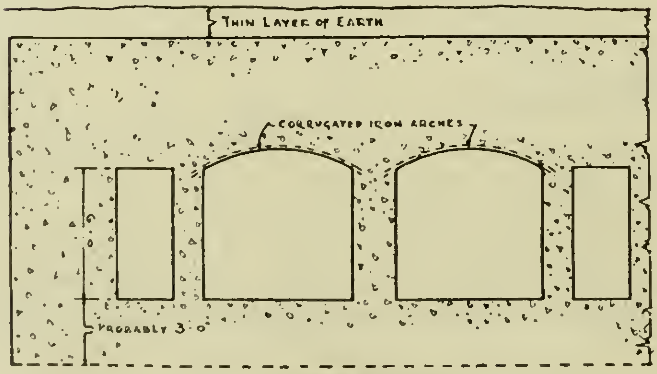
Each of the two interior rooms was ventilated by a small hole through the roof, entering a slot formed in the interior front wall. In one case two additional slits had been cut through the rear wall, for additional light and ventilation. A feature of this type of shelter was the heavy wooden doors at the entrance proper to the interior rooms. These were formed of a layer of 2 in. plank crossed by a layer of 1 in. boards, and were cut horizontally into an upper and lower leaf.



· TYPICAL CONCRETE SHELTER ·
· HINDENBURG LINE NEAR BELLICOURT ·



SECTION THROUGH ENTRANCES AT B B.



·SECTION·A·A·

Fig. 3. A typical concrete shelter in St. Quentin Sector.

MACHINE-GUN EMPLACEMENTS.

The machine-guns firing from the trenches had no elaborately prepared emplacements. The necessary means of access to the parapet from a nearby shelter was prepared and the gun run up into action. Occasionally a semicircular platform of planks was arranged for this purpose, but not often.

There were a number of open machine-gun emplacements of concrete of the type shown in *Fig. 4*, located either in front of or behind the trenches, and con-

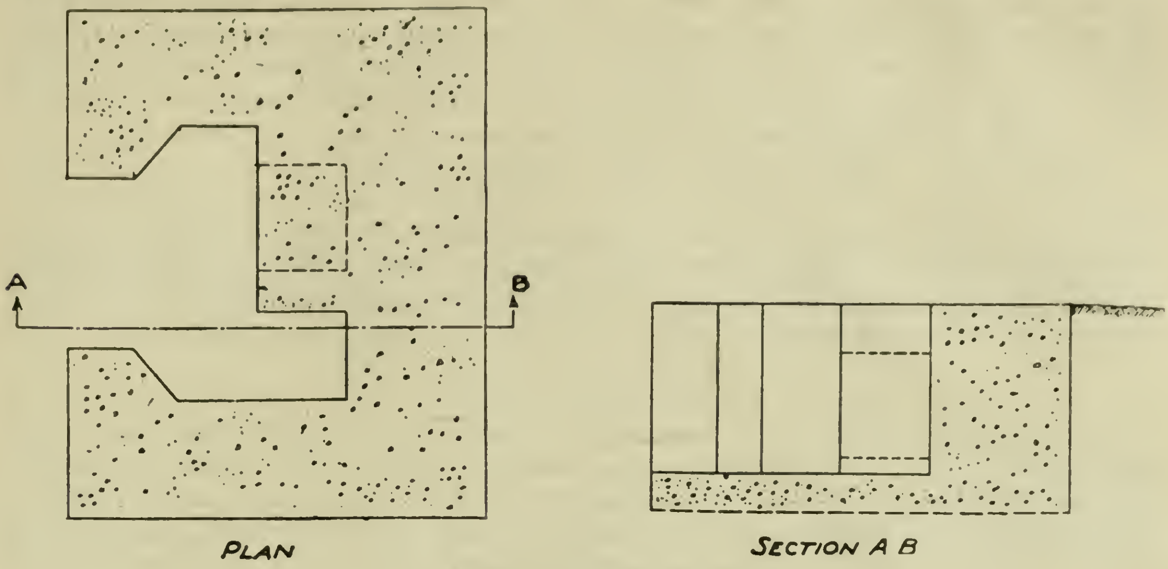


Fig. 4. Machine-Gun Emplacement.

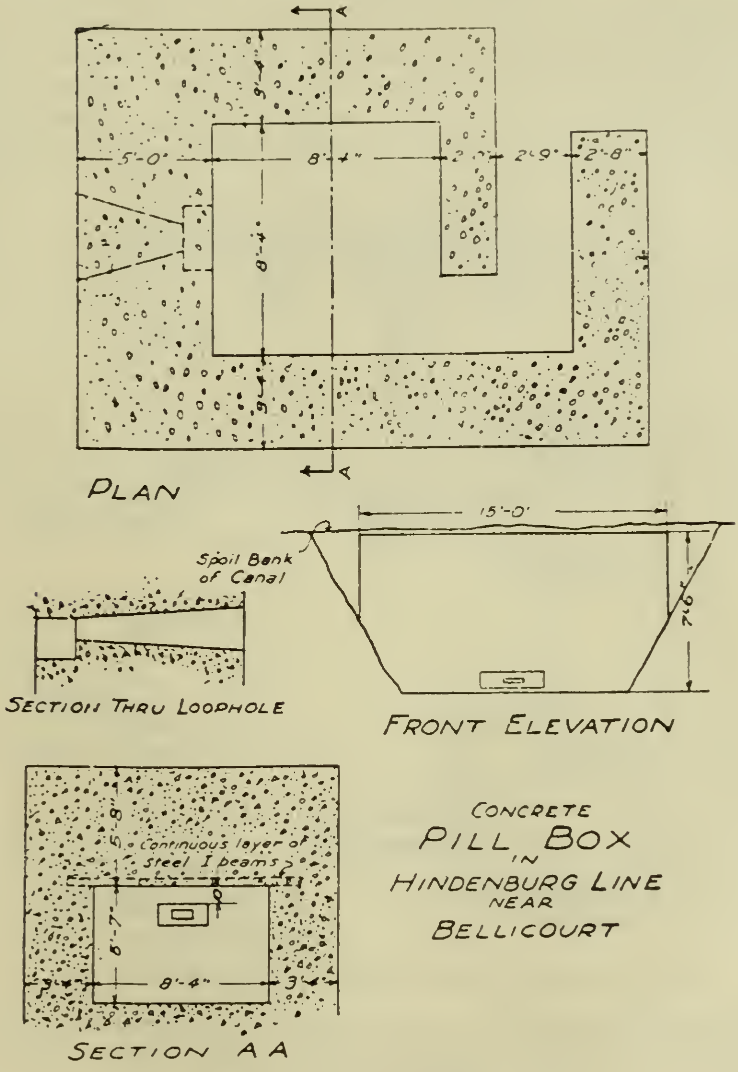


Fig. 5. Concrete Pill Box.

nected by deep underground passages to shelters entered from the trenches. The design of these emplacements, as concerning the firing-stand, was by no means uniform. Some were merely an open concrete box. The thickness of the concrete protection was in all cases 3 ft. or more. These emplacements are very hard to discover, as one happens on them accidentally only, unless one finds them as a consequence of exploring the cave shelter to which they are connected. It is difficult to estimate how many were installed.

Machine-gun emplacements with overhead protection, the so-called pill-boxes, were very few—probably not more than three in the whole sector of the American attack. An example of this type is shown in *Fig.* 5. It was constructed in the spoil bank of the canal, a wide embrasure being excavated in the bank to afford the necessary field of fire. A noticeable feature, common to the type, is the roof formed of closely set I-beams, the lower flanges exposed.

OBSERVATION POSTS.

The position of the lines was such, in general, as to give observation from elevations in rear. Very few observation posts, as such, were discovered. One interesting type of concrete observation post is shown in *Fig.* 6, and consisted of a concrete box set flush with the ground, covered by a steel plate provided with a hole, about 12 in. in diameter, through which the head of the observer or a periscope could be thrust. One such observation station was found on the summit of a mound in the town of Bellicourt, and a pair were found in the midst of the wire in front of the front-line trench, where observation was very good. There are undoubtedly others not discovered. The pair last referred to were installed as a part of an elaborate structure that may be called a concrete listening post. It had two storeys, the plan of the lower being shown in *Fig.* 6. The two observation compartments were placed over the middle two rooms, and an open machine-gun emplacement of the type shown in *Fig.* 4 was placed over the right-hand

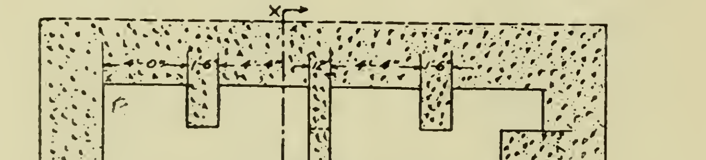


Fig. 6. Combination Observation Post and Machine-Gun Post.

room. Access to the machine-gun emplacement was had through a short trench, entered from this right-hand compartment. The left-hand compartment of the lower story was the entry to a deep, underground passage, leading to a concrete shelter in the parapet of the main front line trench, about 40 yd. in rear of the listening post. In point of fact, this passage seems to have been used by the Germans as a dumping place for empty bottles, discarded equipment, and all manner of rubbish, rather than as an entrance to the advanced post.

REINFORCED CONCRETE.

The concrete used in this section of the line had gravel as an aggregate. Although the gravel had been brought from a considerable distance, there being no local material suitable for making concrete, it was of decidedly inferior quality, there being a large excess of fine aggregate. The concrete was more of a mortar with an admixture of pebbles than a hard mass of cemented stone. Those faces of the various works that were not intended to bear the light of day were very rough and showed many voids. Exposed faces were plastered. The finish of such faces was very good and showed no signs of checking or scaling. One would say that the concrete was mixed much dryer than is the American practice, and that the consequent rough surface holds a plaster coat much more tenaciously than the relatively smooth surface produced by our wet mixture.

From the fact that every broken face—and many not broken—showed reinforcement of a uniform character, one may judge that all concrete in this sector was reinforced on a uniform system. The reinforcement was formed of plain round rods from $\frac{5}{8}$ in. to $\frac{7}{8}$ in. in diameter. These had very evidently been placed in the mass as the concreting progressed, not set and wired before the concreting begun. For this reason there was no uniformity in spacing. It would seem that it was intended that all concrete should have a horizontal course of crossed rods at vertical intervals of something between 6 in. and 1 ft. Each course consisted of two sets of rods, one at right angles to the other; the rods of each set being spaced between 6 in. and 1 ft. apart. This reinforcement was continued throughout the whole mass of the concrete, not concentrated at the top and bottom of the slab. The rods were not cut when the face of the form was reached, but were bent 180° to form the next line of the set. In very many cases the rods showed on the face of the concrete. In addition to the horizontal reinforcement vertical reinforcement was used in the walls of the structure. It was not found in the roofs. None of these reinforced concrete structures were demolished.

NEW BOOKS
AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Loads on Highway Bridge. Report of the Joint Committee, consisting of representatives of the Concrete Institute, The Institution of Municipal and County Engineers, and the Institution of Municipal Engineers. With Appendices by Henry Adams and H. Kempton Dyson.

Publishers: E. & F. N. Spon, Ltd., London, S.W. Price 2 6 net.

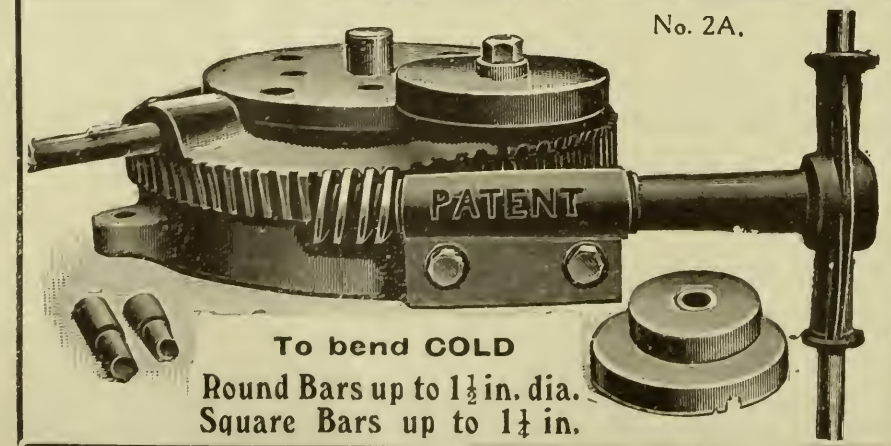
This report which is the work of a committee established in 1911 with Professor Henry Adams as chairman, consists chiefly of a series of standard loadings which should be provided for in designing highway bridges. This standard is based on the result of a large number of enquiries respecting the maximum weights of vehicles and roads in the various localities.

The bending movements and the shear stresses of binders have been calculated for the total live load and are shown in the tables and graphs and three typical examples are fully worked out.

In a valuable appendix by Professor Henry Adams, it is suggested that after long-continued or heavy rainfall upon new roads the maximum axle load permissible should be reduced to two-thirds of that allowed in summer weather. It is also stated that the loads, wheel diameters, and the tyre treads of rollers do not appear to be based on any clear rules, but certain machines are taken as typical and compared with the restrictions imposed by the various Locomotive and Motor Car Acts to 1907. In this connection much further progress in road traffic is impossible until the present state of the law is amended, for it is still the fact that a railway company is only called upon to maintain a bridge strong enough for the traffic at the time the bridge was constructed.

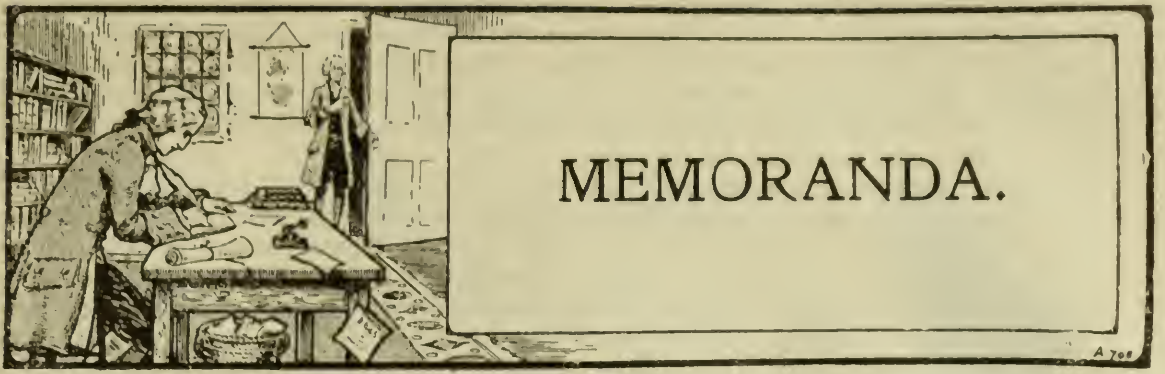
Hence, the use of heavier engines carrying or drawing heavier loads is restricted wherever a railway bridge exists and in some localities the passage of heavy traffic is made impossible. This state of affairs will clearly have to be altered and by presenting the facts in a clear and unbiassed manner the Committee have rendered excellent service to the community.

A second appendix by the secretary of the Concrete Institute explains how the bending moments and shearing forces for beams subjected to moving loads may be calculated in accordance with the customary formulæ. Attention is called to the fact that in continuous beams, where short spans adjoin long ones, there may be an unexpected negative bending in the latter, the supports holding down the ends of the beams and preventing continuity from extending beyond the supports of the adjoining span. Continuous construction therefore requires careful consideration to secure proper stability with economy.



To bend COLD
Round Bars up to 1½ in. dia.
Square Bars up to 1¼ in.

Rods bent COLD
Round or Square
FOR
REINFORCED
CONCRETE
◆ ◆ ◆
W. KENNEDY (Patentee)
26 Brandville Road
West Drayton, Midx.
Send for particulars.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome —ED.

Roads and Transport Congress and Exhibition.—A roads and transport congress will be held at the Royal Agricultural Hall, London, from November 20th to November 27th next. The undertaking is being organised by the County Councils Association with the active co-operation of the Association of Municipal Corporations and the bodies representing urban district councils, rural district councils, municipal and county engineers, and county surveyors.

The main subjects to be dealt with at the conference include :—

(1) Concrete roads, their construction, maintenance, and life ; asphaltic macadam (bituminous) roads, and their extended use ; the consolidation and amendment of the highways law.

(2) The relative advantages of single and double coat road surfacing work carried out in bitumen (as distinct from tar compounds).

(3) The conditions under which the heavier types of vehicles may use the roads, with special reference to their liability for extraordinary traffic damages.

(4) The weight, construction, and speed of mechanically propelled vehicles in relation to the construction and maintenance of roads (one paper to be read by a manufacturer of such vehicles and the other by a road engineer).

(5) Provisions for and development of traffic in the future, with special reference to (*a*) the provision of new roads, (*b*) road finance, and (*c*) provision of new transport services.

The Institution of Municipal and County Engineers are, by agreement with the association, taking steps to hold a housing conference at the Agricultural Hall at such times as road congress meetings are not being held, and it is hoped that a public works exhibition may be held in connection therewith.

Concrete Roads.—We learn that the City Surveyor of Chester (Mr. W. Matthews Jones, M.Inst.C.E.) has recently commenced the laying of a reinforced concrete carriage-way through the main streets of Chester—namely, Eastgate Street and Foregate Street ; also including a double set of tramlines, which run through the centre of these two streets. The estimated amount of traffic passing over those streets per day is about 1,200 tons. These two roads take all the traffic from Manchester, Liverpool and Warrington to North Wales.

Concrete Roads in Australia. In discussing the question of roads in Australia, the *Commonwealth Engineer* makes the following remarks regarding Concrete Roads :—

> " Concrete roads in Australia up to the present time have not been laid down to any appreciable extent, and the reason is not far to seek. Most of the States have an abundance of good road-making material, which provides an excellent wearing surface, and under reasonable conditions and when a suitable binder is used has a satisfactory life. The cost, too, as compared with concrete, is an important consideration. Again, in most of the principal capital cities wood blocks have been provided for the main streets, and authorities claim, and rightly so, that no effective substitute has been found for these, for when surfaced with bitumen the roads are capable of withstanding practically any class of traffic.

But few municipalities are able to bear the heavy cost of wood-blocked bituminous roads, and in their efforts to improve existing conditions must use the material available to the best advantage. The Dominion of New Zealand would appear to be the home of concrete roads on this side of the equator, and while the experience gained so far has not been extensive, the roads which have been laid with this material have proved highly satisfactory. In Auckland the question of improved roads in connection with the general scheme of national development has created a general awakening, and the goal ahead is the formation of concrete roads. Naturally we must look to the United States of America for experiments in this direction, and therefore some particulars obtained by Mr. W. H. Hamer, chief engineer of the Auckland harbour board, who has recently returned from America, should prove interesting. He found that in California there were 4,500 miles of concrete roads. The general practice had been to form a sub-grade, 15 ft. wide, of concrete to a thickness of 4½ in., leaving 3 ft. shoulders on either side of the course. In many parts oiled crushed work was topped off on the concreting. The cost had been £2,200 a mile. From San Francisco to Los Angeles, a distance of 441 miles, was a concrete road of 4½ in. in depth standing excellently. Shingle concrete was found to be not successful and had been abandoned in favour of cube chips. In Seattle 6 in. of concrete had been laid with 2¼ in. of sheet asphalte, but as it had been found that ordinary concrete made as nearly a perfect road as could be made, engineers were now abandoning any toppage on the concrete, not even asphalte or tar. In New York where £20,000,000 had been appropriated for roads, concrete in some instances had been simply laid on a solid earth surface after being rolled.

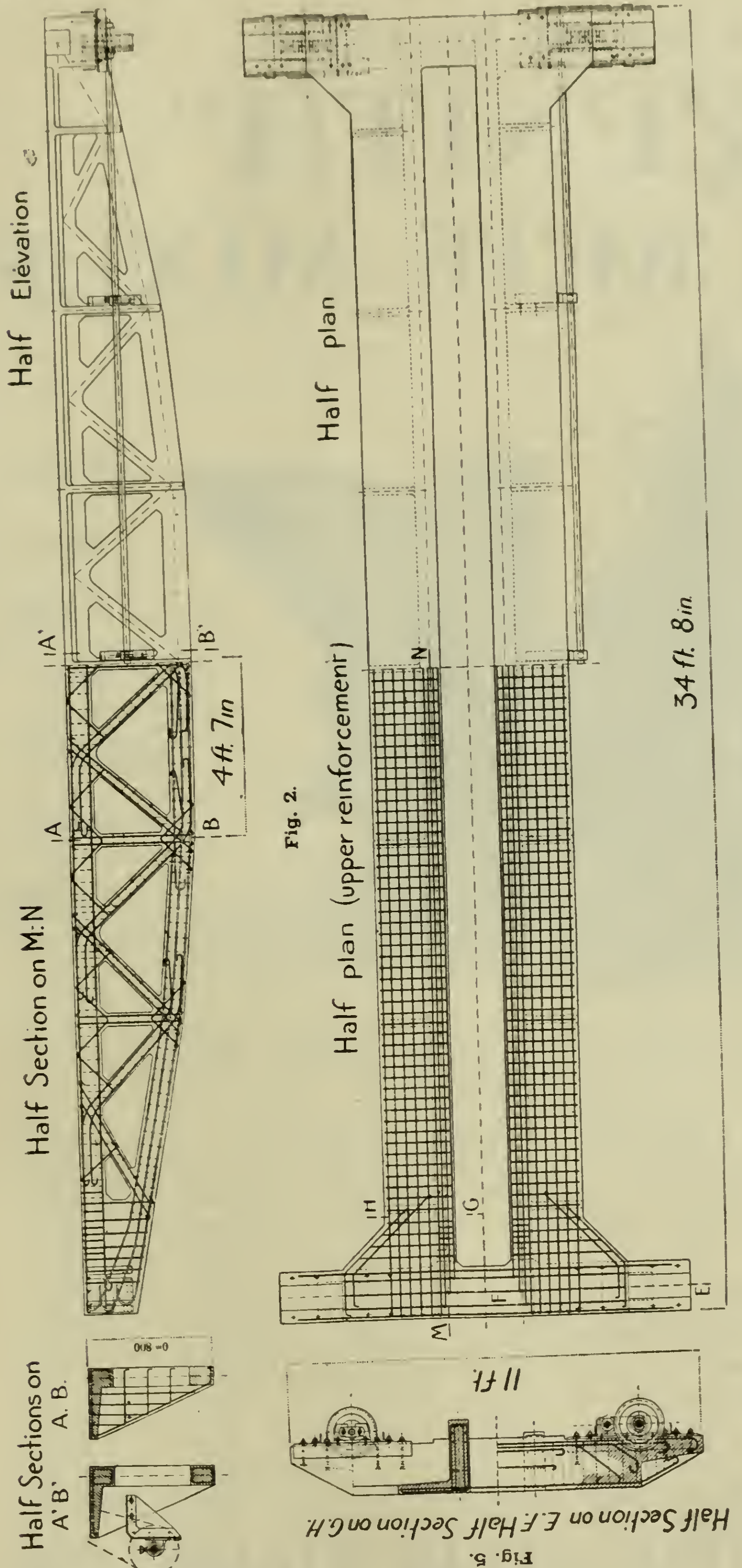
"While it may not be possible to take similar liberties—a 4½ in. depth concrete road, and no metal foundations—with most Australian roads, the fact that the practice has been adopted in some parts of America is conclusive proof of its durability and its capacity to stand up to reasonably heavy traffic. In Quay Street, Auckland, 8 in. of concrete has been laid for a width of 40 ft., the cost being £14,000 a mile. In view of the American experience the question, would a reduced depth have been equally effective? might be asked. At any rate, the evidence clearly shows that concrete roads cannot be further reckoned as an experiment, and while the cost in these parts would appear to be excessively high, the saving in maintenance alone should be something substantial. The principal municipalities in New Zealand are determined to provide improved roads, and as concrete is likely to play an important part the experiments will be watched with interest."

Maidstone to Ashford Main Road.—On this road near Hollingbourne Bridge and the entrance to Leeds Castle there are signs of a settlement on the south side due to the insufficient support of the road owing to the rapid slope of the ground within the park, which here takes the form of a small ravine, with a stream running through it, the bed of which is only 20 ft. from the road and 15 ft. below it. The County Surveyor advised that the movement might be stopped by putting in a continuous concrete kerb, or abutment, on the south edge of the carriage-way and slightly widening the metalling on the north side and by constructing three concrete pipe-shoots, or channels, down the embankment to prevent its erosion. The work is estimated to cost £70, and the Council sanctioned the expenditure.

Concrete Houses. Cost as compared with Bricks.—Replying to a question as to the comparative cost of brick houses and concrete houses, Major Astor states, on August 13th, that "The average cost of brick houses is at present about 1s. 1d. per cubic foot. Houses of a very simple type are being built in concrete as an experiment, and the cost of these houses has been estimated at about 8¾d. per cubic foot. The building of cottages in concrete blocks is being encouraged where suitable materials are available at or near the site."

Concrete Cottages—Dormanstown.—Two concrete houses have been completed at Dormanstown, near Redcar, which have been approved by the authorities. The novel method of building and the quick time in which the two "sample" houses were erected may eventually revolutionise the system of constructing artizans' dwellings.

A Movable Three-Ton Concrete Bridge.—A particularly interesting use of reinforcement is shown in the following illustration of a movable bridge. This bridge has been constructed by the Etablissements Beccat in order to provide a structure of ample strength in which only a minimum amount of steel is used. It was designed so as to cause the least possible trouble with respect to new methods



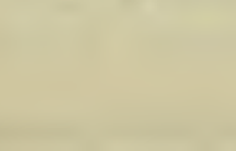


Fig. 2.

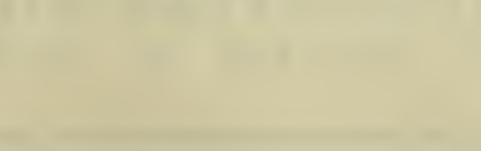
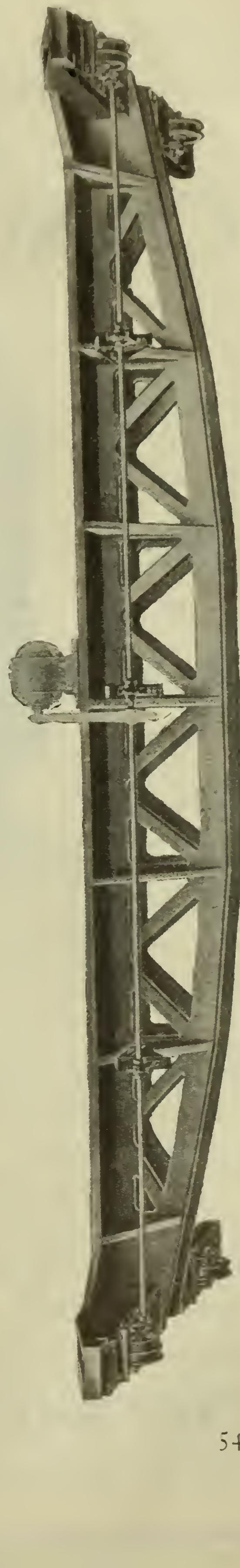


Fig. 5.



A Movable 3-ton Concrete Bridge.

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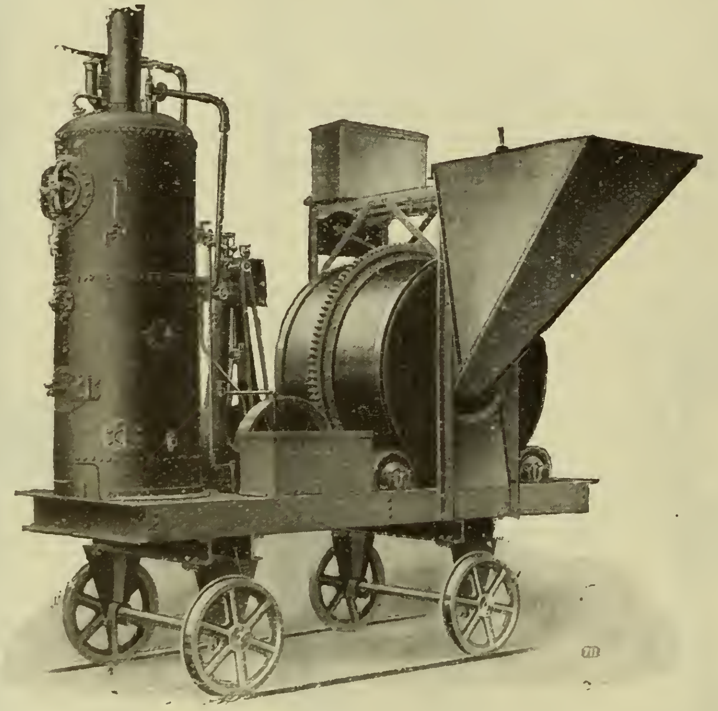

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Nominal batch capacity -		$\frac{1}{4}$ yd.	$\frac{1}{2}$ yd.	$\frac{3}{4}$ yd	1 yd.
Capacity of hopper or skip	cu. ft.	9	18	27	36
Capacity of drum - - -		8	16	24	32
Average outfit per 10-hour day of mixed concrete -	cu. yd.	75	150	225	300
Size of drum (dia. × width) -		3′9″ × 3′0″	4′6″ × 4′0″	5′3″ × 4′0″	5′9″ × 4′6″
Revolutions of Drum per min.		18	16	15	14
Brake horse power - -		4	7	10	15

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and appliances and so that its various parts could be produced by means of the same machinery and workmen previously employed by this firm and other bridge-builders.

The bridge has a total length of 34 ft. 8 in. and an over-all width of 11 ft. at each end, the central segment being 4 ft. 7 in. in length. The concrete consists of a mixture of 1 cwt. of cement to each 154 cu. yds. of gravel and 70 cu. yds. of sand, with a crushing strength of 66 lb. per sq. in. and a coefficient of adhesion to the reinforcement of 66 lb. per sq. in.

The weight of the bridge is consequently only half that of an all-metal structure of the same type. The weight might be still further reduced in future bridges by the use of slags and pebbles in the concrete, whereby an additional strength permits a further reduction of 18 per cent. in the weight of the concrete.

The bridge has been designed so that in the members in compression the maximum load does not exceed 4½ cwt. per sq. in. in any part of the structure and the tensile strain on the steel does not exceed 16,800 lb. per sq. in. The general arrangement of the reinforcement is clearly shown in the illustrations.

Cavities in Concrete.—The following is taken from the *Ironmonger*: Up to the present it has only been possible to make small cavities in concrete, but under a new German patent much larger ones can be made. Pieces of ice, corresponding to the measurements of the cavity required, are embedded in the concrete mass, and small channels are introduced to allow of the rapid drawing off of the melted ice. In this way not only small concrete constructions, such as pillars, stairs, and beams, can be supplied with a hollow space, but large fixed blocks can be supplied with several chambers, such as are required for walls of houses or ships. The process is of particular advantage in reinforcing concrete with iron. The iron parts are not built in during the stamping, but are attached to the ice blocks before the work is begun, which increases its strength. The continual moistening which is required when working on concrete or cement is unnecessary in the new process, as the loss by evaporation is made good by the melted ice, which ensures a complete hardening of the concrete mass. The process can also be applied to artificial stone.

Limestone Kilns.—The subject of limestone products with the urgent need of their development for the housing problem, the land settlement for ex-service men, concrete roads, agriculture, etc., was dealt with by Mr. W. Alden Brown in a paper read, July 25th, before the South Wales Institute of Engineers, and printed in the latest issue of the Institute's *Proceedings*. Pointing out the importance of limestone as an ingredient in Portland cement mixture, the author remarked that lime and Portland cement had been used extensively in the war; in far greater quantities than was generally appreciated. Following the war the demand for these commodities could not be estimated, considering the vast and unlimited possibilities of their uses.

In 1903 the Portland cement production of the world was estimated at 9,800,000 tons. The three largest producing countries were: U.S.A., 3,790,000 tons; Germany, 2,500,000 tons; Great Britain, 1,500,000 tons. In 1913 the world's estimated output of Portland cement was approximately 31,000,000 tons (representing a capital outlay of at least £60,000,000). The three largest producing countries were: U.S.A., 15,500,000 tons; Germany, 5,000,000 tons; Great Britain, 3,000,000 tons. Thus it was apparent that the Portland cement industry held a conspicuous and important position in the world's industries, and its soundness and stability were now of vast interest to the nation both commercially and financially. The immense production to-day had been made possible by the radical changes in the machinery and equipment used in its manufacture.

National Physical Laboratory.—The Lord President of the Council has appointed Professor Joseph Ernest Petavel, D.Sc., F.R.S., M.I.Mech.E., etc., to be Director of the National Physical Laboratory in succession to Sir Richard Glazebrook, C.B., F.R.S., who retires on reaching the age limit on September 18th next.

Professor Petavel is Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester. He is a member of the Advisory Committee for Aeronautics of the Air Ministry. He was educated at University College, London, and undertook scientific research at the Royal Institution and at the Davy Faraday Laboratory until 1898. He was elected John Harling Fellow of the Owens College, Manchester, in 1900, and was Scientific Manager of the Low Temperature Exhibit of the British Royal Commission for the St. Louis Exhibition, 1904.

Manchester School of Technology.—The new session of the School will open on October 8th. Full particulars of the Classes together with prospectus can be obtained on application to the Principal, Manchester School of Technology, Manchester.

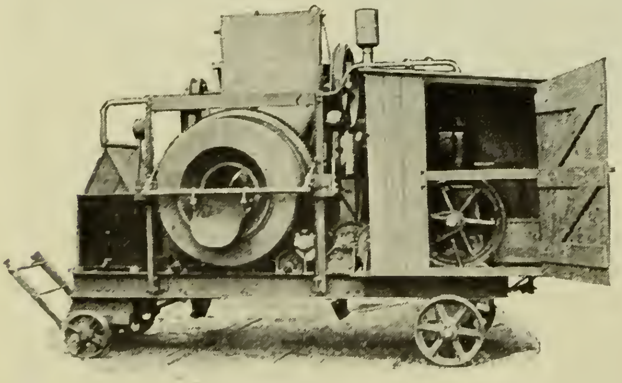
PUBLICATIONS.

The Concrete Utilities Bureau.—We draw the attention of our readers to Pamphlet No. 13, issued by the above Bureau dealing with the use of concrete for Farm and Estate, Home and Garden, Town and Country, Road and Railway. The booklet is fully illustrated with photographs and diagrams, which should be useful to those wishing to make small concrete articles in town or country. This pamphlet as well as previous publications can be obtained on application to the Concrete Utilities Bureau, 6, Lloyds Avenue, London, E.C.3.

" Specification."—At the present time, when the acute dearth of dwellings for the people has brought all matters relating to building very prominently before the notice of the public, the forthcoming issue of *Specification*, of which Mr. Frederick Chatterton, F.R.I.B.A., is the newly-appointed editor, will be looked for with more than usual interest. It will contain, together with much technical matter of direct value to Architects, Surveyors and Municipal Engineers, a number of specially contributed articles on a variety of subjects, such as " The Progress of the National Housing Movement," " Bungalows," and " Domestic Cooking on Oil Stoves."

TRADE NOTE.

A New Pressure Machine for Concrete Blocks.—Messrs. Winget, Ltd., have sent us a catalogue illustrating their new pressure machine for making concrete blocks and designed to meet an increasing demand for blocks and slabs where light labour is available and where their larger machine is not required. This machine can be worked with the lightest of unskilled labour and is easy to operate. We are informed that at least fifty blocks 18 in. by 9 in. by 4½ in., or 16 in. by 9 in. by 4½ in. can be produced on this pressure machine per hour. Partition slabs of the same superficial area as the blocks above-mentioned and of three thicknesses, 2 in., 2½ in. or 3 in., can also be manufactured on this machine. Full details and illustrated catalogues may be obtained from Messrs. Winget, Ltd., 25, Victoria Street, Westminster, London, S.W.1.



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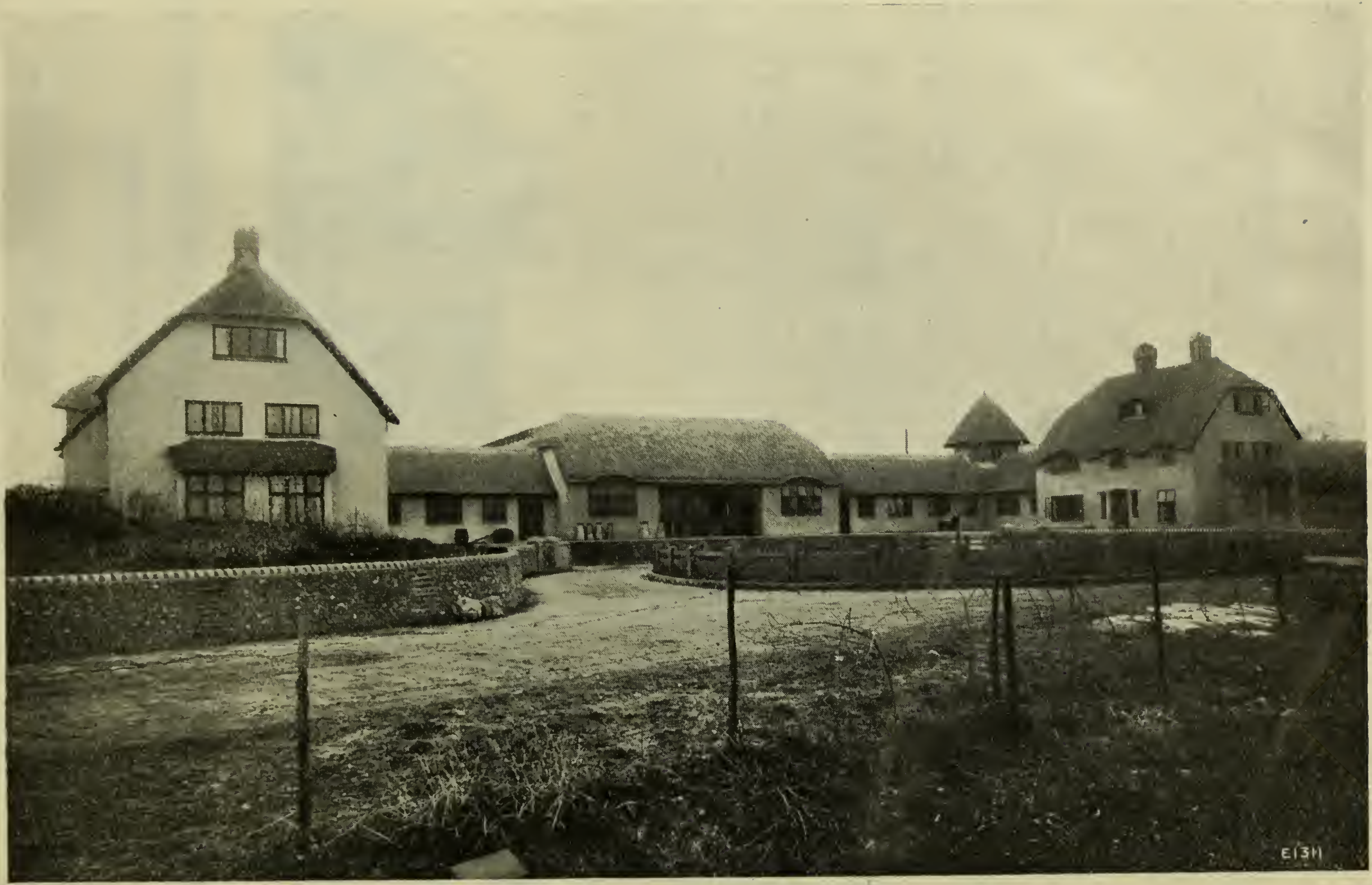


FARM BUILDINGS AND DAIRY IN DORSETSHIRE.
(*See page* 557.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 10. LONDON, OCTOBER, 1919.

EDITORIAL NOTES.

STANDARD SPECIFICATION FOR COTTAGES.

A STANDARD form of specification for State-aided housing schemes has been issued, and any schemes which had not gone to tender at the time of issue must comply with this, otherwise the Ministry of Health will not be prepared to give its approval. The document is, therefore, of tremendous importance, as it fixes the class of work to be done in each trade for thousands of buildings, and lays down a standard practice which is likely to have considerable influence on the specifications for all domestic work for many years to come. The only variation that can be made are those necessary to adapt the work to local conditions and to deal with the special requirements of any particular works, and such alterations as are necessary must be made in red ink on the standard form and initialled by the architect. A general note is added to the effect that in view of its present scarcity, timber should not be used when other materials of equal or less cost and of equal efficiency can be substituted.

POSSIBLE DISADVANTAGE.

The only disadvantage that may follow the issue of an official document of this kind is the tendency for those who inspect the work on behalf of the Government to insist strictly on the letter of the specification without any regard to the spirit, and in a similar manner to that adopted in connection with all building by-laws which hamper the progressive man and give no scope for ingenuity. It frequently happens that an architect wishes to execute some particular piece of work in a special manner to suit peculiar circumstances, and although he can show that the work when so executed will be quite equal, if not superior to that called for in the by-laws, and the authorities will admit the fact, they still insist on the letter of the by-laws being complied with, regardless of the reasons which inspired the framing of the clause applicable. The same tendency is likely to be found with a standard specification, and some latitude is therefore necessary to allow compliance with the general principles without the actual letter being rigidly adhered to.

STANDARD DESIRABLE.

Apart from this possible disadvantage the specification is likely to prove extremely useful, because it sets out the class of work required to obtain the approval of the Ministry of Health, and thus makes for speed in getting matters settled, and also it ensures that all schemes will be executed on a generally universal basis, which is essential in the interests of the taxpayers, who will be called upon to bear a large burden. Standard houses are not desirable, but a standard class of work in the execution of domestic buildings is very necessary.

It is satisfactory to note that in many instances alternative methods of construction are described, and the designer therefore has some latitude in this respect. The descriptions are necessarily somewhat general in character and therefore some details will require to be added before the specification can be considered as complete for the purpose of the builder.

SOME IMPORTANT ITEMS.

It is impossible to deal with the whole of the items here, but attention may be called to one or two matters which are particularly important. In item No. 24, which deals with gullies, we notice that an open channel 2 ft. long is to be provided for taking the sink waste, and this is to be considered as unnecessary. In the first place it involves additional cost, and secondly it is not so sanitary or efficient as the method of discharging the waste into a back inlet gully direct below the grating. The open channel is a relic of obsolete by-laws, and it results in the accumulation of grease and objectionable matter in the channel and on the grating, which causes offensive smells, and the benefit of a good flush into the gully itself is lost.

It is interesting to note that the fencing is specified to be formed with reinforced concrete posts and three rows of No. 8 gauge galvanised wire, and another important point is that in item 37 it is specified that no brick footings are to be provided in any walls. These two items certainly indicate a progressive policy which is quite at variance with the other instance mentioned above. No provision is made for concrete walls other than those built in two thicknesses with slabs 3½ in. or 4 in. thick and not more than 3 ft. long and 12 in. high, and it is curious to note that all division ground floor walls carrying upper floor joists are to be 4½ brick and other partitions are to be built with 3-in. concrete slabs. It would be advisable in many cases to use concrete partitions throughout, and where carrying floors these can be 4 in. thick, and bricks should not be specified without the alternative. Asbestos tiles do not appear in the specification, and therefore are apparently not acceptable, and this is somewhat surprising. It would have been preferable if a separate heading had been given to concrete wherever this material was applicable as an alternative, as we see that the description of suspended concrete floors comes under the heading of "Carpenter and Joiner" in spite of the fact that no mention is made of centering in connection with same. No provision is made for the adoption of concrete staircases when concrete floors are used for the upper storey, and this seems to be an omission. Many similar matters might be mentioned, but we give these few items as an indication that the specification cannot be considered a perfect one for its purpose. A part of the specification is published in this issue and will be completed in succeeding numbers.

DAMPNESS IN CONCRETE COTTAGES.

One of the most frequent complaints made against concrete buildings, especially those of the domestic class, is that they are damp and unhealthy, and we publish in this issue a short article on the subject of protection against dampness, translated from a French journal, which may be of interest. The complaints usually arise from one of two causes—viz., (*a*) the concrete walls are of porous material, and no cavity has been provided, or (*b*) the concrete is so dense that considerable condensation occurs on the inner surfaces when a sudden change takes place in the temperature. It will take much persuasion to convince a tenant that the latter is not due to water penetrating the wall from the outside, and in any case it is, of course, objectionable. There is no doubt that it is quite possible to make concrete absolutely weathertight, and condensation trouble can be overcome by the application of a coating of porous plaster on the inside, but the best type of wall is undoubtedly that built in two leaves with a cavity between, as with this method a perfectly satisfactory building can be obtained at a minimum cost. A proper damp course is essential, and it is important to remember that the cavity should extend at least 6 in. below this damp course, otherwise it will be useless. There are no new ideas expressed in the article above mentioned, but it contains matters of interest, while it deals with a subject which is not usually sufficiently considered in the erection of concrete buildings. We would like to stimulate more interest on this aspect of concrete work generally because there is likely to be an extensive use of the material in connection with the housing schemes now going forward, and faulty application will lead to condemnation on the part of the public occupying such dwellings, which will react seriously on the progress of what is undoubtedly an eminently suitable material for even the most exposed situations.

CONCRETE ROADS.

In our last issue we published a brief programme of the Roads and Transport Congress and Exhibition which is to take place in London next month. We notice that concrete for road construction is down for discussion, and we trust that the question will receive that consideration and attention which it undoubtedly deserves. While we do not for one moment wish to contend that the concrete road is suitable everywhere and for all purposes, yet we are convinced that it should be given a fair trial in our road-building schemes. In spite of the great developments in this direction in America, and the many experiments that have been made in this country, our authorities, as a whole, are still very reluctant to embark on this form of road-building to any great extent. There are probably a variety of reasons for this to which we may have occasion to refer later.

On the other hand, we shall, in the near future, have to construct a very large number of new roads in connection with the various housing schemes which are being planned all over the country, and if these rural communities are to be properly linked up with one another and with the larger towns, durable and good wearing roads will become a necessity, for we may safely assume that a far greater amount of traffic will pass over them than in the past and that it will be principally of the motor type. This being the case, some considerable improvement will have to take place in our main country roads, which have already suffered largely on account of the motor traffic that has passed over them in more recent years, and especially during the period of war.

We are unable to do more than make a passing reference to the matter this month, but we would conclude by mentioning an interesting article that has recently been published by Mr. Eltinge Breed, chief engineer, New York City, dealing with the highway expenditure of New York State generally. He points out in that article the immense cost to the country in maintenance where non-durable types of construction have been employed at the outset. In a table which we reproduce below he sets out the existing and reconstructed mileage for surfacing as at January 1st, 1918, in New York State, from which it will be seen that the surfacing on which no *reconstruction* work had to be done was cement concrete, stone block, sheet asphalt, asphalt block, bituminous macadam, mixed method on concrete and bitulithic.

	Mileage non-existing.	Mileage that had to be reconstructed.	Total of miles built.
Gravel and waterbound macadam (gravel 125 miles)	2,248	1,402	3,650
Bituminous macadam penetration method	3,346	120	3,466
Second class concrete (carpet top)	163	53	216
Rocmac rock asphalt	29	10	39
Bituminous macadam (mixing method) on macadam	37	6	43
Brick	552	3	555
Cement concrete	408	—	408
Bituminous macadam (mixing method) on concrete	63	—	63
Stone block	22	—	22
Bitulithic	16	—	16
Sheet asphalt	15	—	15
Asphalt block	13	—	13
	6,912	1,594	8,506

Thus, in order to retain possession of 6,912 miles of pavement, 1,594 additional miles had to be built.

As Mr. Breed very truly points out in the course of his article, a road is not the possession of one village, it belongs to the whole country and should be built for the welfare of all.

OBITUARY NOTICE.

The Late Mr. Edwin O. Sachs.

We much regret to announce the death of Mr. Edwin O. Sachs, F.R.S.Ed., F.R.G.S., our consulting editor and chairman of the British Fire Prevention Committee, which took place on September 9th, after a prolonged illness. Mr. Sachs was born in London in 1870, and was educated at University College, London. He spent some years on the Continent studying architecture and the fire-fighting and fire-protective services. He started practice as an architect in London in 1892, and during the early years of his practice he wrote and published a work entitled, *Modern Opera Houses and Theatres.* Up to the time of his death he was consulting architect to the Grand Opera Syndicate, Covent Garden Theatre. He designed and superintended the erection of several large factories, and was architect to the Egyptian Government for the Khedival Opera House, Cairo; he designed Walmer Place, and other country and town residences, and specialised in large factory works, amongst those designed and erected by him being Siemens' Works, Dalston, and the Asbestos Works, Higham.

It is, however, mainly by his interest and activity in relation to fire protection and fire prevention that he will be remembered, and in this connection we would recall the particular services he rendered to concrete building construction by the formation of the Concrete Aggregates Commission. This Commission was formed many years ago with a view to investigating the relative values of different concrete aggregates for their fire-resisting qualities. A series of tests were undertaken at the British Fire Prevention Committee's testing station, and the results were duly published in the Committee's usual "Red Book" form. Mr. Sachs was further instrumental in the setting up of the Reinforced Concrete Committee of the International Testing Association, and served on that Committee for many years. In 1908 he founded the Concrete Institute, and was nominated its first chairman.

The Bee House.

A CONCRETE BLOCK-BUILT HAMLET IN DORSET.

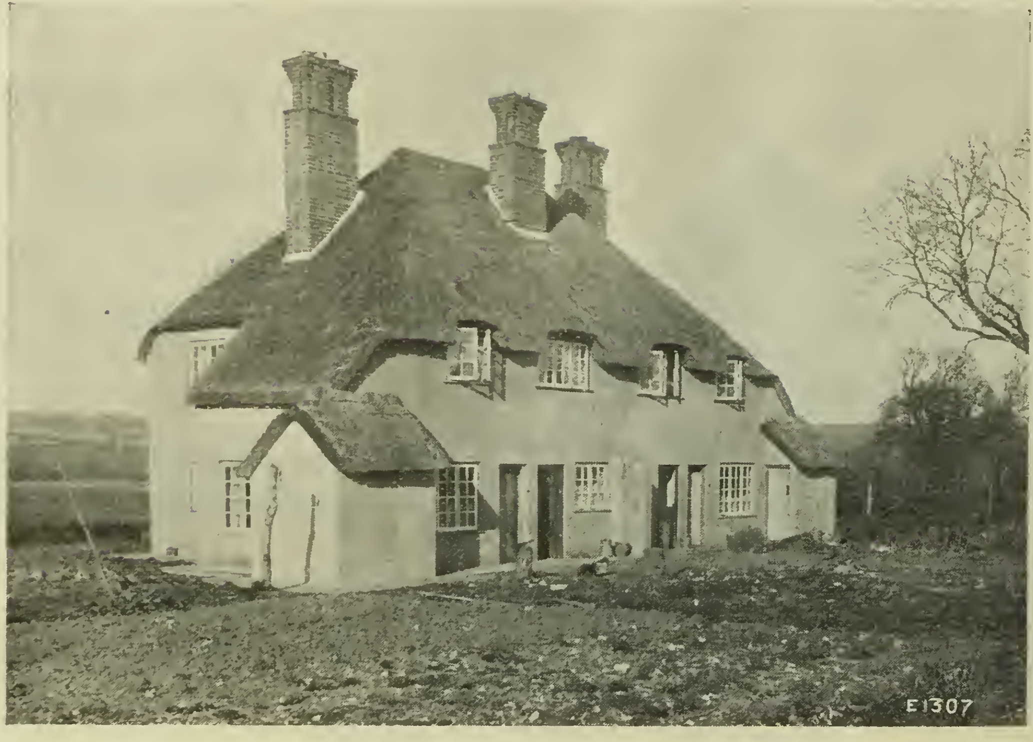
By ERNEST G. W. SOUSTER, A.R.I.B.A.

THE present high cost of building operations and the greatly increased price of bricks, coupled with the need of thousands of new dwellings, which must be built within a comparatively short time, has made the use of concrete a necessity.

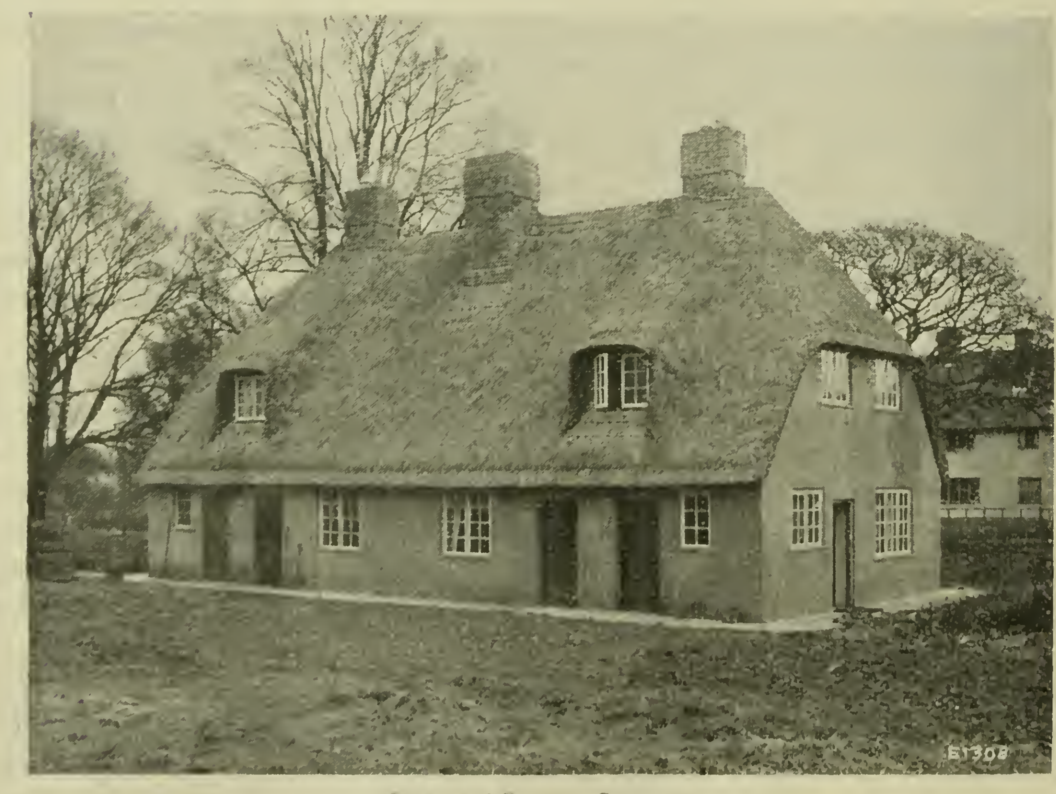
Previous to the war reinforced and plain concrete had been experimentally used for a few dwellings, but the past five years have proved its adaptability for economically housing thousands of soldiers and munition workers, and where sand and gravel suitable for the aggregate are to hand the cost of a dwelling of this material will be much cheaper than one of brick or even timber framing and, again, the overloaded transport services of the country will be somewhat relieved.

Turning to hygienic conditions it will be admitted at once that concrete buildings are not liable to decay and rot, and they also possess vermin-proof qualities that cannot be obtained with the old-fashioned and, what may be termed normal, methods of construction. It must, however, be admitted that thin concrete slabs, and, in a lesser degree monolithic concrete walls, will allow for condensation on the inner surfaces, but the introduction of a narrow insulating space will greatly reduce this disadvantage, a fact that has been realised by many concrete block makers.

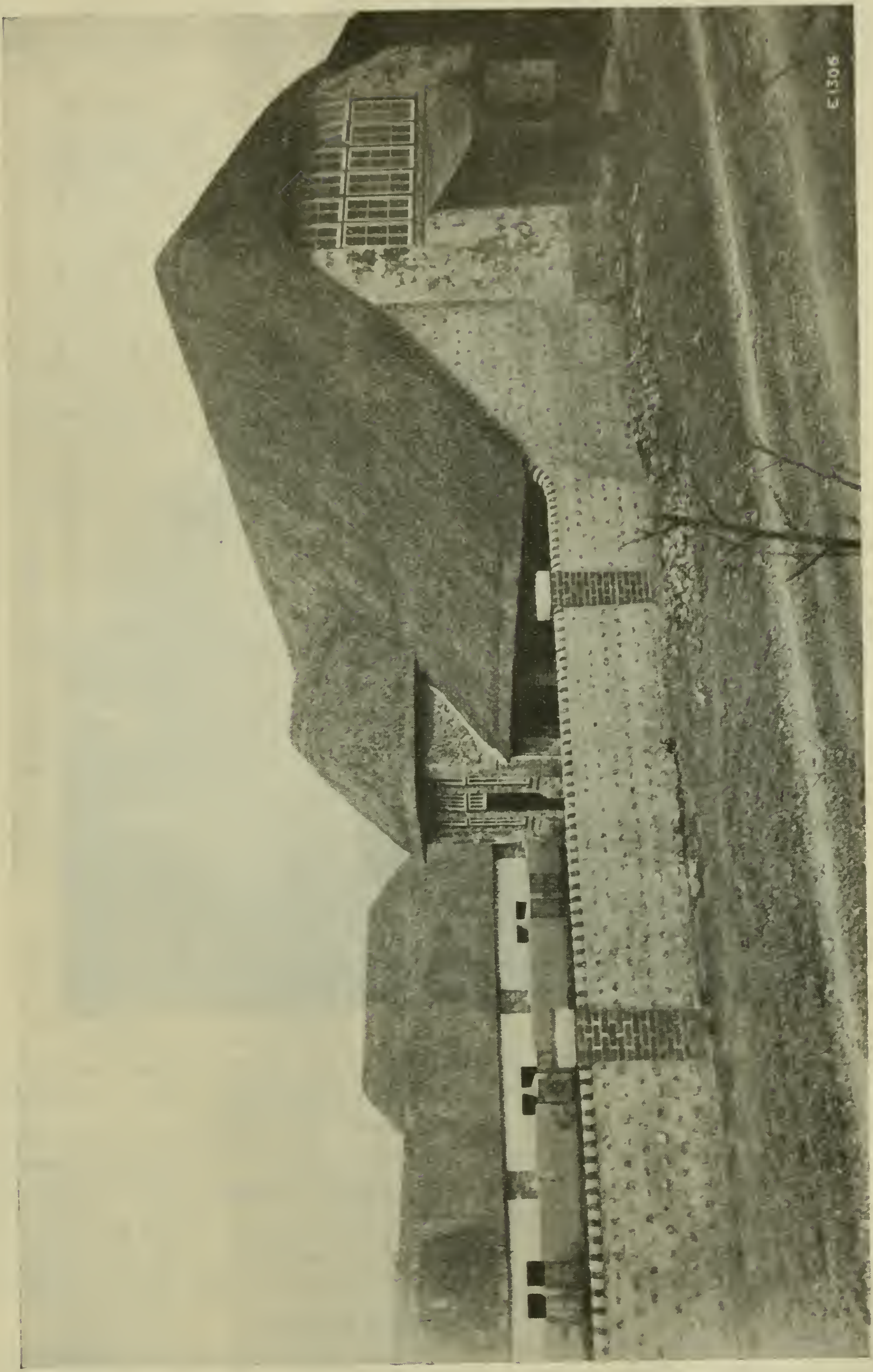
Experiments have been made to eliminate this condensation by making the block of two different mixtures, one for outer face and one for inner, for the general consensus of opinion to-day is, that a continuous insulating space is necessary around any concrete structure that is adapted for human habitation, and though this is readily obtained by building two separate walls the expense involved renders the plan unsuitable where economy is essential.



Group of Cottages.

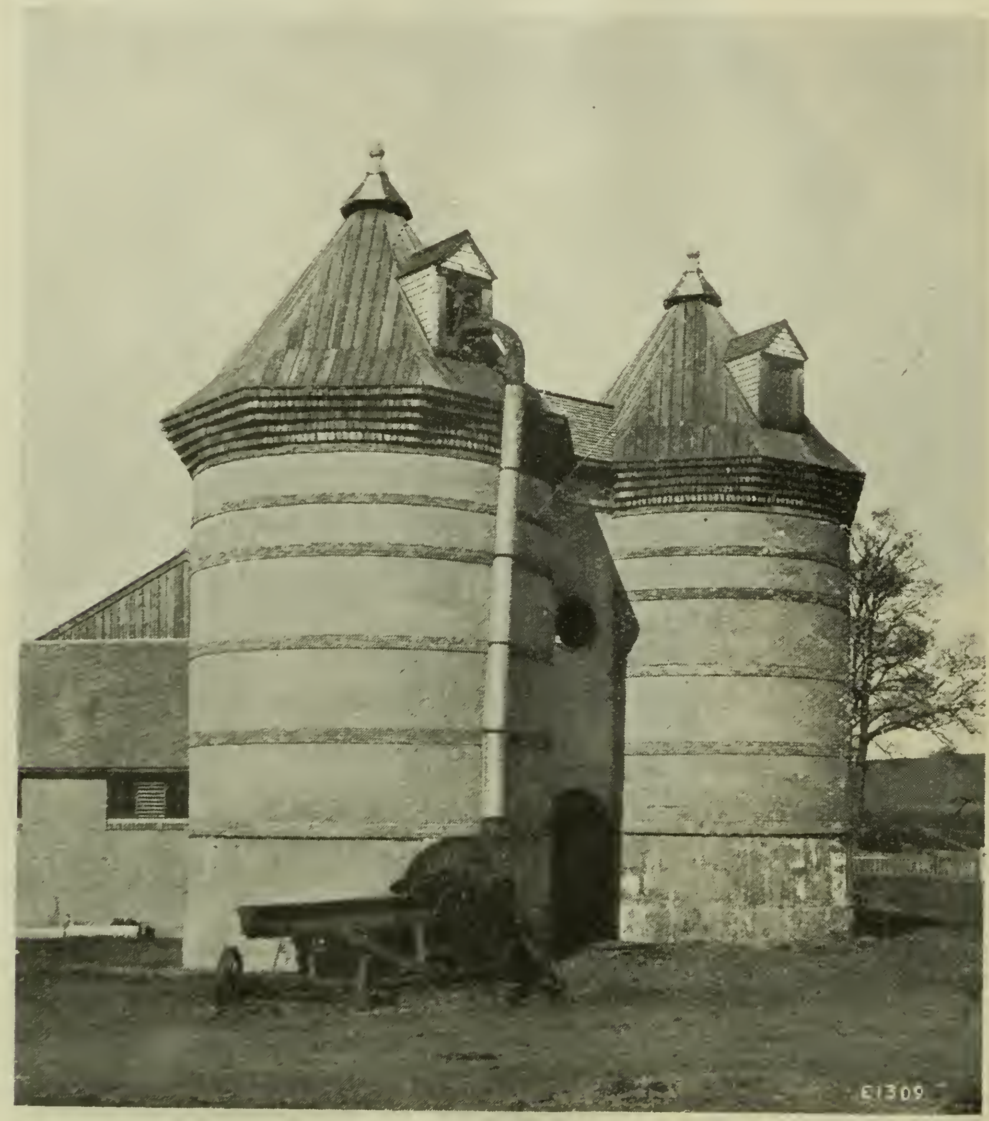


Pair of 6 Roomed Cottages.



THE FARM BARN.

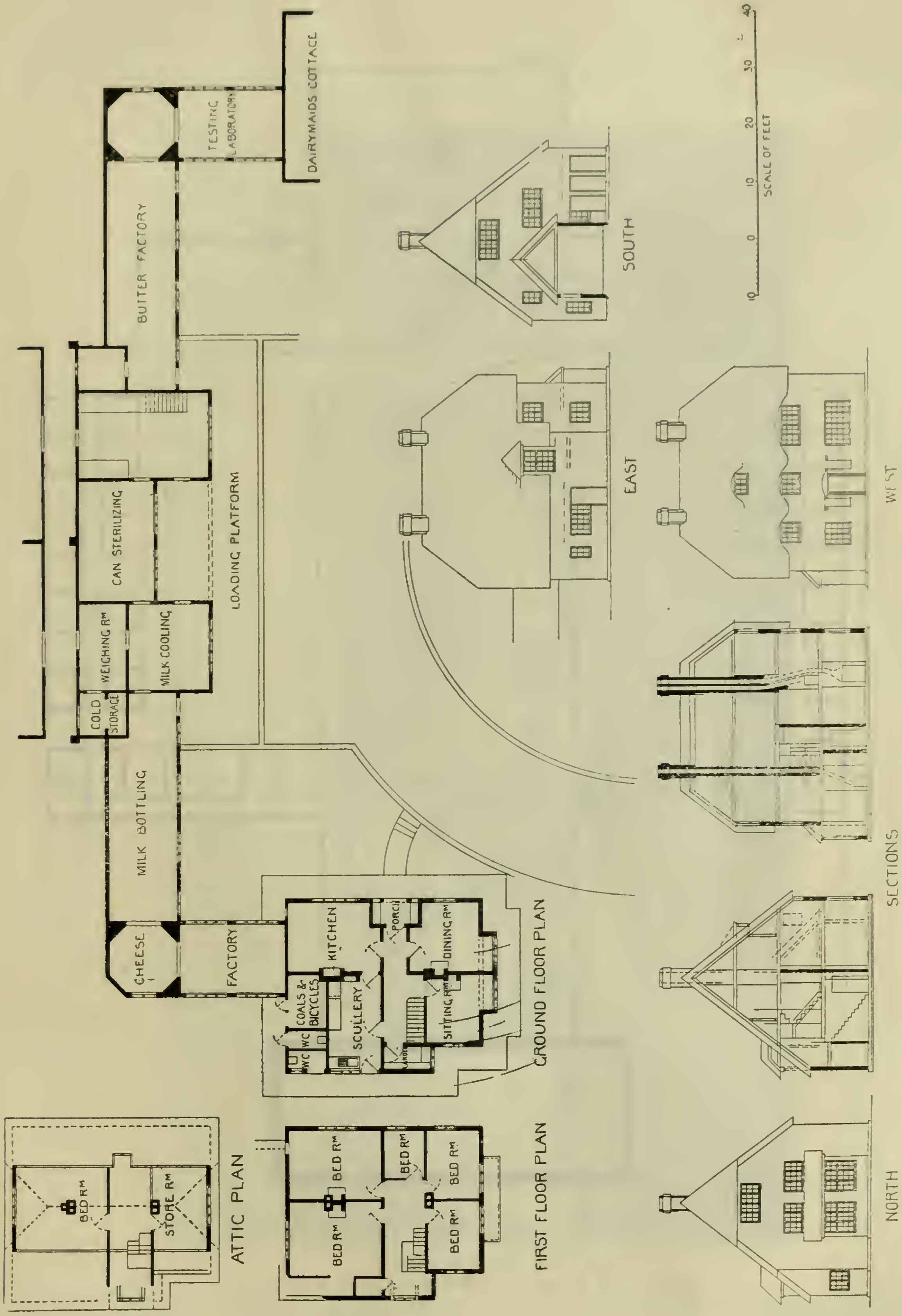
The cottages and farm buildings which form the subject of this article have all been erected with concrete blocks made on the " Léan block system," which is claimed by the inventor to entirely eliminate all risk of condensation within the building.



The Silos.

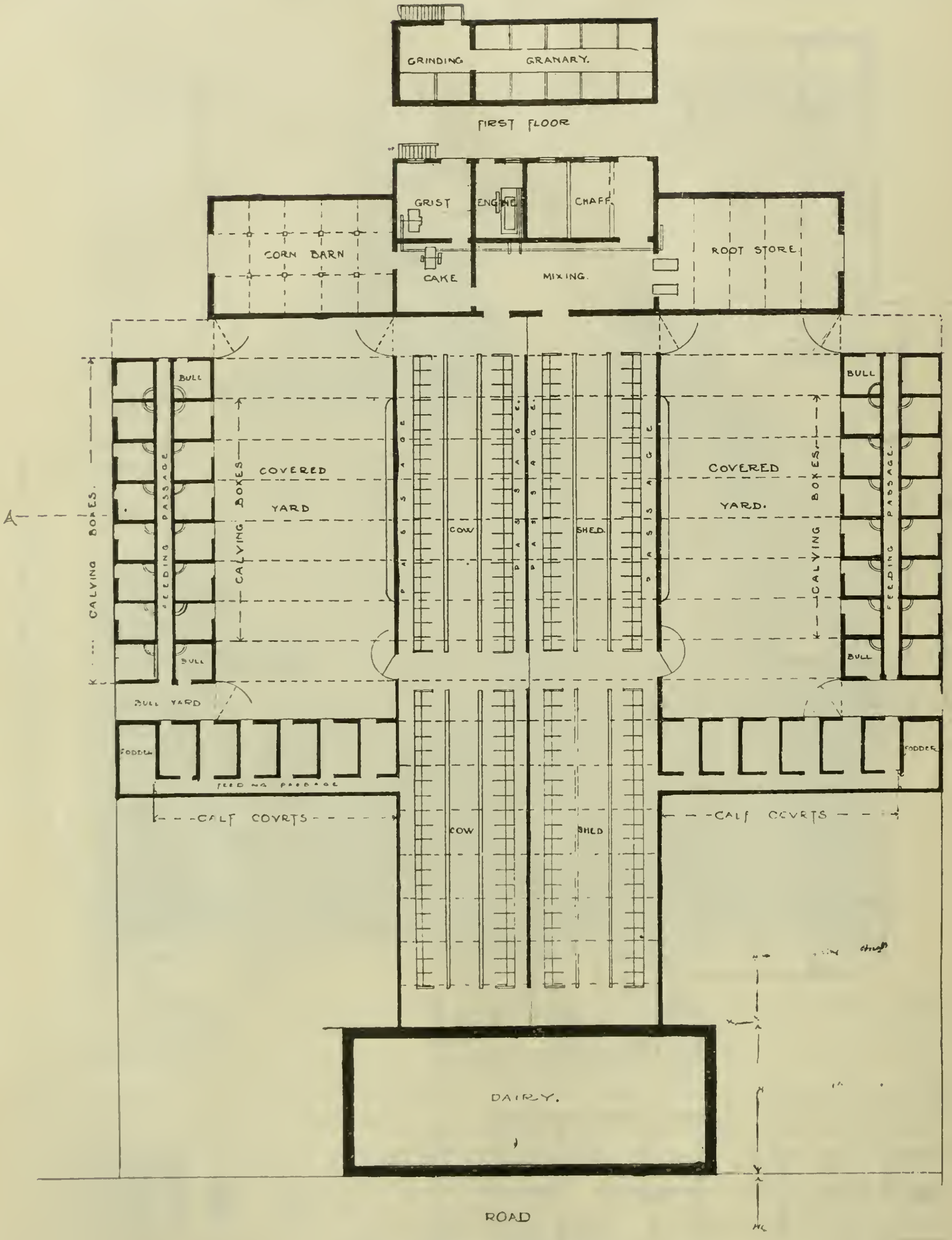
The blocks, which are 8 in. in thickness, have three longitudinal spaces between their inner and outer faces and are so shaped that when two blocks are placed in position there are as many channels between the inner and outer faces as exist in the blocks themselves. By this means the continuous through joints are avoided and, in consequence of the connecting strings being dimensioned in a way that is in correct proportion to the surrounding air within the wall, the disadvantage of the usual joint is neutralised. At the floor and roof levels a continuous reinforced concrete beam is formed which not only receives timbers or edges of floors but also ties the whole structure together.

The farm buildings and cottages illustrated have been erected during the past five years on an estate in Dorset and form part of a scheme which has been designed on the lines of a model garden village.



Plan of Cottage and Dairy.

A Concrete Block-built Hamlet in Dorset.



Plan of part of farm buildings.
A Concrete Block-built Hamlet in Dorset."

So far each cottage has a flower garden at front, vegetable garden and small orchard at back, whilst at the end of each plot a pig-sty and fowl-house has been erected and the owner's desire is that each tenant shall, whilst working on the farm, have the opportunity of developing his plot so that he becomes a successful cottage holder. In other words, instead of the worker being entirely dependent upon his holding he shall draw a regular salary from the large home farm and in his spare time qualify for the experience necessary to manage and prosperously develop a small holding.

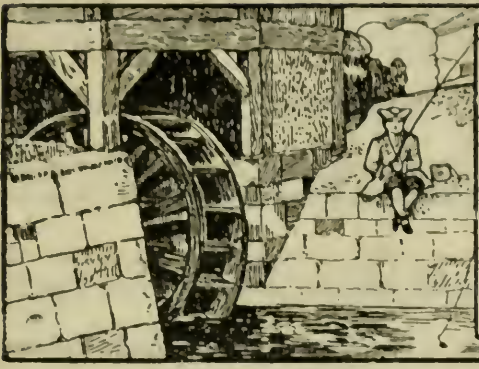
A Dairy Barn.

The cottages are of several types and vary from six to eight rooms, and in each a bath and fittings that provide for the amenities of decent civilisation have been installed. As already stated, the walls are of concrete blocks and the same material has been used for the internal partitions, whilst to prevent dampness from reaching the outer surfaces of the blocks a coating of lime cement plaster has been applied to all external faces.

The fireplaces and chimney stacks are of brickwork, this material being more adaptable than concrete for the flues and portions of building that could not be readily standardised.

The floors and roof construction are of timber and all roofs are thatched except those over the barn and silos, the latter of which are of oak shingles, the silo walls themselves being of reinforced concrete.

Mr. Halsey Ricardo was responsible for the designs of the farm and dairy buildings, but the detail design, the design of the cottages and their general lay-out have been carried out by Mr. Macdonald Gill, who acted as resident architect of the whole hamlet and to whom we are indebted for the loan of the photographs and drawings and for the foregoing information.



STANDARD SPECIFICATION FOR COTTAGES.

THE following is the standard form of specifications for State-aided housing schemes, with which all schemes which have not gone to tender, or were not at the point of going to tender, at the date of the issue of the Memorandum must comply. The specification is to be adapted to local conditions and to the requirements of the particular works by alterations made in red ink and initialled by the architect. Excep, where variations from this standard form are rendered desirable by local conditionss the Ministry of Health will not be prepared to approve of schemes which show deviationt from this form. In view of its present scarcity, timber should not be used where other materials of equal or less cost and of equal efficiency can be substituted.

SPECIFICATION OF WORKS TO BE EXECUTED AND MATERIALS TO BE PROVIDED FOR THE ERECTION AND COMPLETION OF COTTAGES.

This specification with the drawings of the respective types of cottages forms part of the contract between   and

1. *Preliminaries.*—The work to be done under this specification is intended to include all the general work preparatory to its execution; for the compliance by the contractor with all the conditions of the contract; for the plant, scaffolding, tools, and sheds; proper and sufficient protective works; notices, licences, and fees; for fire, workmen and other insurances; mess rooms for workmen; regular clearance of rubbish; and for all other matters necessary for the completion of the several works satisfactory to the true intent and meaning of the drawings and this specification. Adequate latrine accommodation is to be provided and kept in a proper sanitary condition, and wherever practicable a connection is to be made immediately with public sewerage for the same, and the trapping and ventilation thereto are to be carried out in accordance with the regulations. Clear away the latrines and soil whenever necessary, and make good at completion all work disturbed by the erection of these conveniences. Provide the water necessary for the use of the works. Provide all necessary appliances for keeping the trenches and excavations free from water during the execution of the works. Provide a suitable office, with the necessary heating, lighting, furniture, and sanitary accommodation, for the use of the architect when he is visiting the works, and for the clerk of works and for all attendance during the period of the work. Provide the necessary watchman for the protection of the works, and such lighting as may be found necessary. Provide any protection around the site that may be necessary for the public safety. Attend upon, cut away for, and make good after all trades in all trades. Protect and keep free from damage due to the operations under the contract, all fences, paths, trees, shrubs, greens, and other surfaces about the buildings or approaches thereto which are required to be maintained.

EXCAVATOR AND CONCRETE.

2. *Surface Soil.*—Carefully remove and preserve any turf and stack where directed. Remove the vegetable earth or other surface soil to the depth required under the houses, and deposit the material in separate heaps for use or for clearing away eventually, and clear away what is not needed. All excavation is to be disposed of on the site, if possible.

3. *Trench Digging.*—Excavate below the foregoing level for the trenches required for the foundations to all the walls, piers, chimney breasts and other work indicated on the drawings to the lengths, widths, and depths shown, or to greater depths should the earth at the levels indicated not be sufficiently solid for a good foundation. Level the bottoms of the trenches for the concrete.

4. *Strutting and Planking.*—Strut and plank all excavations wherever necessary.

5. *Filling In.*—Fill in and ram the best of the excavated earth about the foundation of walls, etc., and deposit or clear away the surplus as required.

6. *Consolidate Earth.*—Well level, ram, and consolidate the earth below all floors and pavings, concrete, etc. All trench bottoms are to be inspected and approved by the architect before any concrete is laid therein.

7. *Lime.*—Where suitable blue lias or stone lime can be obtained locally they can, except as hereinafter specified, be used in place of Portland cement.

8. *Cement.*—The Portland cement is to be of approved manufacture, of a quality which complies with the requirements of a current specification adopted by the British Engineering Standards Committee slow setting quality to be used generally.

9. *Gauging Concrete, Mortar, etc.*—Provide the necessary boxes for accurately measuring the ingredients for concrete, mortar, plastering, etc. All gauging and mixing is to be performed on proper wooden platforms.

10. *Aggregate for Concrete.*—The aggregate for concrete is to be composed of hard bricks free from lime, mortar, stone, gravel, or other approved material broken to various sizes, but all to pass through a 1½ in. ring, with sufficient clean river or pit sand to fill up all interstices.

11. *Concrete in Trenches.*—For the foundations of all walls, piers, chimney breasts, etc., concrete of the sections shown on the plans, and composed of one part by measure of cement to eight parts by measure of the aggregate and sand, is to be laid in the trenches and carefully levelled to receive the brickwork. If ground lime is substituted for cement, it must be gauged six and one for hydraulic lime, and four and one for stone lime.

The materials are to be well mixed in small quantities by turning over with a rake and shovel until the colour of the cement is distributed over the aggregate, and then with a due proportion of water, which is to be applied through a rose, and the concrete so prepared is to be at once deposited into the trenches and well consolidated.

12. *Foundations.*—Excavate for and lay Portland cement or lime concrete foundations, as described those to external and party walls to be not less than 12 in. wider than bottom of wall, those to internal walls to be not less than 9 in. wider—none to be less than 6 in. thick. The bottom of concrete is to be not less than 2 ft. below the level of the finished ground outside the houses, but in clay soils the bottom of the concrete must not be less than 3 ft. 6 in. below the level of the finished ground outside the houses. The bottoms of all concrete foundations to walls must in all cases go at least 9 in. into the virgin soil, except where the foundation is in shale, chalk, rock, or other ground of a like nature, when the bottom of the concrete can commence directly either of these materials is met with.

13. *Concrete on Sloping Sites.*—In steeply sloping sites in clay, where the foundations owing to the natural slope of the ground would come at or near the surface they are to be taken down at least two feet into the virgin soil.

14. *Surface Concrete.*—Lay over the whole surface of the buildings a bed not less than 4 in. thick of Portland cement concrete similarly composed to that described for the trenches, levelled and prepared where necessary to receive such other floors and pavings thereon as may be specified.

15. *Granolithic Paving, etc.*—The floors in scullery, w.c., e.c., coal store, larder and back lobby are to be finished with a 1 in. thickness of cement and either limestone or granite chippings (two of cement to five of the material used) brought up to a hard, smooth, trowelled surface and kept damp for seven days after laying.

16. *Concrete Lintels.*—The concrete lintels are to be composed of one part of Portland cement, four parts of the aggregate to pass 1 in. ring, and two parts of sand. The lintels are to be reinforced by a steel rod ½ in. diameter for openings up to 4 ft. wide and ¾ in. diameter for openings above 4 ft. wide for every half brick in thickness of the wall carried, or for every 6 in. in thickness where stone walls are supported. The lintels are to be 6 in. deep for all apertures up to 4 ft. in clear width and 1 in. deep for each additional foot or part of 1 ft. beyond 4 ft. The lintels are to bear 6 in. on the walls at each end.

17. *Concrete Eaves Course.*—If a projecting eaves course is desired, it may be formed of similar concrete to that last described, not less than 4 in. thick and reinforced with ½ in. diameter steel rods at right angles to the wall spaced 2 ft. apart near the upper surface and finished with roughcast or cement and sand or harled as described in "Plasterer." Where these occur over window openings they are to be cast in long lengths to act as lintels with two ½ in. diameter steel rods embedded lengthwise in the same in addition to the rods above specified. The wall plate carrying rafters must be bedded on the inner edge of the concrete eaves course.

OUTSIDE PATHS AND PAVINGS.

18. *Paths and Paving in Yards.*—All pavings, gravel or ash paths are to be carefully laid to fall towards approved drainage courses. Excavate for and form the back garden paths with 3 in. of ashes well rolled in. Excavate for and form the front path up to entrance doorway, also the paved portion at back of houses, with tar paving 2 in. thick of macadam, slag, granite, or other similar clean material

broken to pass a 1 in. mesh and containing a proper proportion of fine material and hot pitch and tar well mixed together and punned into position and well rolled. Finish with ½ in. layer of similar materials to pass a ¼ in. mesh well rolled and finally sprinkled with white stone or spar chips and again rolled. The ½ in. finishing coat is to be executed just before the houses are handed over ready for occupation. The tar paving is to be laid upon 3 in. of ashes well rolled in. Provide and fix at edge of tar paving 1¼ in. by 4 in. creosoted fir sawn edging, secured with 1½ in. by 1½ in. creosoted stakes 2 ft. long, pointed and driven into the ground at 4 ft. centres, or other suitable approved edging. The front path may be formed of cobbles, rough stone paving, or other suitable material.

DRAINAGE.

19. *Soil Drain Pipes.*—The pipes for soil drains are to be "British Standard Tested," and to comply with the British Standard Specification No. 65 for salt-glazed ware pipes, with socket joints and all necessary bends and junctions, laid to straight runs and to even and regular falls on a bed of Portland cement concrete (1 to 8), as described for foundations 4 in. thick, and to be benched up at each side to top of pipe with similar concrete. Pipes under building are to be surrounded with similar concrete 4 in. thick. Pipes are to be laid not less than 18 in. deep below the surface of gardens and 12 in. deep below pavings. The joints of pipes are to be caulked with gaskin and jointed in Portland cement and sand in equal proportions, and the inside of pipes is to be carefully cleaned out so as to leave a perfectly clear and unobstructed waterway.

20. *Rainwater Drains.*—The pipes for rainwater drains are to "British Standard," and to comply with the British Standard Specification No. 65 for salt-glazed ware pipes, laid as above but without concrete.

21. *Falls.*—The soil and rainwater drains are to be laid to even and regular falls of not less than 2 in. in 10 ft.

22. *Filling.*—In filling in the trench after the drains are laid and tested, great care is to be exercised so as not to disturb the drains, and the finest and best of the excavated material is to be used for packing around the pipes. The whole is to be carefully and thoroughly consolidated and rammed, and any depressions in the finished surface over drains made up.

23. *Cleaning Eyes.*—Form cleaning eyes where required on drains with sloping length of 4 in. salt-glazed ware drainpipe carried up to surface of ground and finished with salt-glazed ware stopper bedded in cartgrease and sand in end of pipe. Surround end of pipe with cement concrete 6 in. thick, and cover the cleaning eye with 2 in. cast concrete slab, 15 in. by 15 in.

24. *Gullies.*—Provide and set where necessary to take surface water and at feet of rainwater pipes, bath and sink wastes, 4 in. salt-glaze ware trapped reversible gullies, with rebated top and 6 in. by 6 in. heavy cast-iron grating. Bed and surround the gullies with Portland cement concrete and joint to drain. Provide and fix at side of gullies taking sink waste 4 in. salt-glazed open channel 2 ft. long discharging over gully and set in cement concrete not less than 6 in. thick. Form brick or Portland cement concrete curb around all gullies (except surface water gullies), and finish in Portland cement and sand, gauged 1 and 3, with rounded top, and render the wall of house next gully with cement and sand 9 in. high. Finish with return and arris at top, and continue the curb around the open channel of gullies taking sink wastes.

25. *Manholes.*—Build manholes in the positions required by the local authority, and of 2 ft. 3 in. by 1 ft. 10½ in. minimum size, with 4½ in. brick sides to those 3 ft. deep and 9 in. brick sides to those exceeding 3 ft. deep, in cement mortar upon Portland cement concrete bottom 4 in. thick, the bottom benched up with steep falls to channels in fine Portland cement concrete and the bottom and sides rendered water-tight in cement and sand. Provide approved cast-iron coated manhole cover and frame, 18 in. by 18 in., 24 in. by 18 in., or 24 in. by 24 in. clear opening as required, bed the frame in cement and the cover in cartgrease and sand. Provide 4 in. cast Portland cement concrete surround finished in 1 in. granolithic on top as previously described, to take cover. Provide and bed in cement in bottom of manhole salt-glazed ware half round main channel pipes, and similar three-quarter round branch channel bends. Manholes over 3 ft. deep are to have cast-iron step-irons built into side 18 in. apart.

26. *Intercepting Trap.*—Provide and build into side of manhole nearest the sewer an approved salt-glazed ware intercepting trap, with cleaning arm and stopper bedded in cartgrease and sand, and bed trap on and surround with Portland cement concrete and connect to drain. Provide and fix galvanised-iron lever and chain to the stopper, the chain fixed to wall of manhole just under the cover with a stout staple.

27. *Ventilating Pipe and Fresh-Air Inlet.*—Provide and fix at upper end of drainage system 3½ in. diameter cast-iron coated ventilating pipe, as hereafter described in "Plumber." Provide and fix in a protected position near the front manhole an approved fresh-air inlet, formed by carrying up a drain connected to manhole 6 in. above level of ground, with a bend on the end, and bed same in

Portland cement concrete, benched up and rendered smooth, and fix in the end of the bend a galvanised cast-iron grating set in cement.

28. *Connections to Sewers.*—Where new roads are in course of construction, or are about to be constructed, the connection to the sewer in road is to be made before the footpaths and roadways are completed.

29. *Testing.*—No length of drain is to be covered in until it has been tested and passed. The whole of the soil drainage system is to be tested again at completion with water, smoke, or other test to the satisfaction of the local authority, and is to be well flushed out at completion of works.

FENCING.

30. *Fences and Gates.*—Construct the fences at front, back, sides, and between houses with three rows of No. 8 gauge galvanised iron wire well strained and fixed through holes in concrete posts and secured to the end posts with ¼ in. diameter galvanised iron eye bolts passing through holes in the post and with nuts and washers. The posts are to be 4 in. by 3 in. tapered reinforced concrete posts 3 ft. high above ground with the exposed surfaces perfectly clean and smooth, let into ground 18 in. deep and shaped at top. The reinforcement is to be kept ¾ in. back from the finished surfaces of posts. The end and corner posts where taking full strain of the wires are to be 4 in. by 4 in. and to have reinforced concrete struts, and the feet of posts and struts are to be set in Portland cement concrete 18 in. by 18 in. by 18 in. The entrance gates and the gates in the back fences are to be wrot iron or oak of approved simple design, with latch and heavy catch bolted to the concrete post and hung on stout wrot-iron rides with nuts and washers and passing through holes in the gateposts. The gateposts are to be 4 in. by 4 in. reinforced concrete posts, shaped at top, 4 ft. high above ground, let into the ground 2 ft. deep. The gateposts are to have sunk holes so that the nuts of bolts do not project. The feet of gateposts are to be set in Portland cement concrete 18 in. by 18 in. by 18 in. Other kinds of fencing, if of equal cost and durability, can be used in place of the foregoing.

31. *Dividing Walls at Back of Houses.*—Dividing walls at back of houses 6 ft. high and 5 ft. projection are to be put where there are no outbuildings.

BRICKLAYER.

32. *Bricks.*—The whole of the building bricks used are to be good, hard, well burnt, common bricks. Where London stocks can be obtained, approved grizzles or place bricks may be used for party walls and internal walls carrying no weight. Approved old bricks, where available, may also be used. The bricks are to be picked square and true for faced work. No bricks are to be used for facing which will scale or waste away when exposed to frost or rain. All bricks below dampcourse in contact with earth or damp are to be carefully selected hard burnt bricks, not liable to be affected by the action of the earth or damp.

33. *Lime Mortar.*—The lime mortar is to be composed of one part of blue lias lump lime and three parts of clean, sharp river or pit sand, or one part of stone lump lime and two parts of sand, and should the lime be ground before use, the proportions are to be four and one and three and one respectively.

34. *Cement Mortar.*—The cement mortar is to be composed of one part by measure of Portland cement to four parts by measure of clean, sharp sand, and when mixed is to be used immediately No cement mortar that has commenced to set is to be knocked up again.

35. *Mortar Mill.*—Where a mortar mill is used, the proportion of sand shall not be less than. one-third of the aggregate.

36. *Brickwork.*—The whole of the walls, piers, chimneys, etc., are to be built of the lengths, heights and thicknesses shown on the drawings, well flushed up in Portland cement or lime mortar, and the cross joints filled in solidly; the work is to be carried up to even heights all round, and no part is to rise more than scaffold height above any adjoining work. If porous bricks are made use of above the dampcourse, the external face must be finished in cement, roughcast or harled, as described in "Plasterer." No main external brick wall is to be less than 9 in. thick.

37. *Footings.*—No brick footings are to be provided to any walls.

38. *Brick Hollow Walls.*—The hollow walls are to be built of two 4½ in. brick walls with a 2 in. cavity and with galvanised iron ties, two at least for every superficial yard, and one to every 12 in height to the sides of all openings. The base of the wall is to be filled in solid with fine concrete up to 6 in. below level of dampcourse. Great care is to be observed to keep bottom of cavity clear of mortar droppings, and sufficient bricks, which can be removed for clearing out cavity at completion, must be laid dry at the bottom of the cavity. These bricks are then to be properly reset in cement.

39. *Concrete Slab Hollow Walls.*—The hollow walls may be built of two thicknesses of 3½ in. or 4 in. concrete slabs with a 2 in. cavity, and set in cement mortar bonded together with approved galvanised iron wall ties 3 ft. apart horizontally and every course vertically, and placed diagonally, all as described for brick hollow walls. If this method of construction be adopted, the outside leaf can be cast weathertight, or roughcast or harled, as described in "Plasterer." The concrete slabs can be composed of one part of Portland cement to six parts of fine clean clinker, free from sulphur,

cast in moulds, under pressure, with slightly hollowed or grooved edges, and properly seasoned before use. The slabs are to be not more than 3 ft. long and 12 in. high. These hollow concrete walls are to be built on ordinary concrete or on brick foundations up to, at least, the level of the dampcourse.

40. *Arches.*—All arches are to be segmental or semicircular half-brick rings set in cement mortar. Brick on edge flat arches may be used to openings not exceeding 4 ft. wide with ½ in. camber.

41. *Pointing.*—All the joints of brickwork are to be well filled in, flushed up and neatly weather struck, where exposed as facings, as the work proceeds when the weather permits. The brickwork is to be either left rough or well raked out where the finishing is to be in roughcast or harled.

42. *Work in Cement.*—The half-brick walls and the chimney stacks, where they rise above the levels of the roof coverings, are to be built in cement mortar. The outer casings to flues above roof are to be 4½ in. thick.

43. *Party Wall Gables.*—The party wall gables or divisions in roofs are to be 9 in. thick, stepped, and finished on top with at least 3 in. clinker concrete carefully brought up to the line of the roof slope for nailing roof coverings to without the use of battens, for protection from fire.

44. *Sundries.*—Build in as the work proceeds, or afterwards bed in lime and hair mortar and point in cement mortar around all joiner's frames for doors and windows ; bed in mortar all beams, sleepers, and plates, lintels, templates, slips, stone and metal work set in the brickwork.

45. *Wire Reinforcement.*—Where half-brick walls are used to enclose coal stores provide and build in at 1 ft. 6 in. and 3 ft. above floor level approved galvanised wire mesh as reinforcement to strengthen the walls to resist the coal thrown in.

46. *Partitions.*—All division ground floor walls carrying upper floor joists are to be 4½ in. brick. Build the internal partitions where indicated on the drawings with 3 in. concrete slabs, as previously described, set in cement mortar and well pinned in and tied to the brick walls. Where a second upper storey is to be formed, 3 in. partitions may be used on the first floor, but in cases where these partitions carry the second floor joists they must come immediately over 4½ in. brick walls on the ground floor.

47. *Sleeper Walls.*—Where there are wooden joists to the ground floors, build 4½ in. honeycomb sleeper walls, and 4½ in. solid brick fender walls.

48. *Dampcourses.*—Lay on all walls, piers, chimney breasts, sleeper and fender walls, etc., a dampcourse the full thicknesses of walls formed of two courses of stout slates breaking joint, set in cement mortar gauged three and one ; or an approved pure bitumen dampcourse well lapped and set upon a bed floated to receive the same may be used. Lay over the ground floor openings and opening in gables of hollow walls approved pure bitumen dampcourses turned up over the inner concrete lintels and dressed down in the hollow with a slight fall each way and 3 in. beyond the width of the opening, and taken to within ½ in. of face of external wall. Slate dampcourses are to be laid in all the chimney stacks at the point where they rise above roofs.

49. *Flues and Chimney Heads.*—Build the necessary corbelling over for the breasts and stacks, form all chimney flues of the sizes shown, which are in no case to be straight or less than 9 in. by 9 in. with as easy bends and turns as possible, and properly gather and parge the flues as the work proceeds and core at completion. The chimney stacks where so shown are to have projecting courses at their heads, and each flue is to be finished with a chimney-pot set and well flaunched up in cement mortar.

50. *Chimney Openings.*—Build in kitchen range openings 2 in. by ⅜ in. cambered and caulked iron chimney bars 18 in. longer than the opening and turn one-ring arches over them and at all fireplace apertures, and carefully gather in the flues immediately above the openings. Concrete lintels may be built in instead of arches or bars.

51. *Concrete Hearths.*—Where indicated on drawings prepare for a self-setting range by forming a large concrete hearth 4 in. thick finished hard and smooth with 1 in. granolithic paving, and make a smokeproof connection to the brick flue from the iron flue pipe of the range. Form similar concrete and granolithic hearths to other fireplaces on ground floor. Concrete hearths 3 in. thick, finished with 1 in. granolithic paving, are to be set generally upon fillets nailed to the upper floor joists. No timber or plugs are to be inserted within 6 in. of any flue.

52. *Trimmer Arches.*—Where concrete hearths are not used, 4½ in. brick trimmer arches are to be turned between the timbering on proper springing fillets and filled in solidly with cement concrete to receive the 1 in. granolithic paving.

53. *Stoves, etc.*—Fix and bed solid all stoves, ranges, mantelpieces, etc., provided, and make good all round after fixing : provide and build in firebricks in all flues where exposed to flames.

54. *Mantel to Range.*—The mantel to range may be formed in cement, slate, stone or brick with wood shelf over.

55. *Rendering.*—Roughly render the faces of brickwork or walling over smoke flues passing through floors, ceilings, and in roof spaces with cement mortar.

56. *Copper.*—Provide and fix in the positions indicated on the plans independent eight to ten

gallon rustless iron pans, with furnaces for gas or other fuel, with iron flue pipes and bends to connect with brick flues above.

57. *Air Bricks.*—Two 9 in. by 6 in. air bricks are to be built in the external walls for each larder and e.c. and for each w.c. and one 12 in. by 9 in. air brick is to be built in for each bedroom having no fireplace. Proper cased flues for same are to be formed through cavity walls.

58. *Ventilation Under Floors.*—Where wood floors on joists are used on the ground floor a through current of air is to be provided through every space so covered by an adequate number of 9 in. by 3 in. air bricks built in as last. Where any part of the building has a solid floor, then through ventilation is to be provided to the spaces under joisted floors by 4 in. socketed drainpipes connected to a flue and air brick built in the external wall.

59. *Sink.*—Provide and fix a Standard pattern Belfast or London sink with waste and trap in each scullery set in cement mortar on two 4 in. drainpipes solidly filled up with concrete in front and resting on two brick corbels at back.

60. *Steps.*—Set in cement all stone, brick, tile, or granolithic concrete steps; the steps in each case are to be finished 2 in. above the levels of the floors at the front door, but level with the pavings of lobbies and sculleries and in similar positions.

61. *Window Sills.*—Where window sills are adopted they may be of stone, brick, or concrete, or of two courses of plain tiles, bedded in cement and set projecting 2 in., the bottom course having a continuous nib. The tiles are to be set weathering. Stone, brick, and concrete sills are to project 2 in. and to be throated on the underside.

62. *Reveals and Sills.*—Where hollow walls are unplastered, put thick slates or other approved materials to the reveals and sills, set in cement mortar to cover wall cavities as necessary.

63. *Larder Bench.*—The bench in the larder is to be natural stone, patent stone, granolithic, or slate slabs on projecting brick courses built in cement.

64. *Fair Face to Brickwork.*—Finish the interior walls of scullery, larder, w.c., e.c., back entrance lobby, coal store, and outbuildings with a fair face and point with a neat, flat joint for lime-white or distemper.

65. *General.*—Do all necessary rough cutting, beam-filling, and everything required to complete the bricklayer's work to the satisfaction of the architect.

WALLER.

66. *Walls.*—Where stone is procurable locally and the cost compares favourably with that of brickwork, stone walling may be substituted for brickwork. The stone walling must be at least 12 in. in thickness. Build up from the concrete in trenches the external walls of the lengths, heights, and thicknesses indicated on the drawings in uncoursed rubble set in lime mortar as described for the brickwork, inserting a sufficient number of through bonding stones and large quoin stones. Where it is intended to face the walls with stone, the whole is to be built with random rubble set in lime mortar, and the joints struck as the work proceeds when the weather permits. Carefully dress the quoins to all the apertures and at the salient angles. Form arches, or finish the heads over the apertures with squared stones as indicated on the plans. Build in cement all the chimney heads up from just below the roof with coursed rubble, having dressed stones and oversailing courses as shown, and point as above described. The external faces of stone walls may be roughcast or harled as described in "Plasterer." The dampcourses will be as described for those in the brick walls, and the specification for bricklayer's work will generally apply to the waller's work.

TILER.

67. *Tiles.*—Tiles should not be used for roofs with a pitch of less than 45 degs. The tiles are to be hard, well and evenly burnt sand-faced tiles of an approved make and colour, made with nibs and laid on to a 4 in. gauge, but not less than a 2 in. lap throughout. The tiles are to be laid on 1½ in. by 1 in. sawn battens, and every fifth course is to be nailed with two 2 in. stout composition nails to each tile. The two courses next to all eaves, gables, hips and ridges are to be nailed each course. Where no fascia or soffit boards are provided the tiles are to be nailed to 1 in. rough boarding between the eaves and wallplate. All tiling may be pointed or torched on the underside in the manner customary in the district.

68. *Verges.*—The verges are to be formed with tile and a half tiles, with a tile undercloak, pointed in cement, exposing the ends of the tiles.

69. *Eaves.*—Put a double course of tiles at all eaves, bedded in cement mortar.

70. *Ridges.*—Cover the ridges with half-round or other approved section ridge tiles bedded down solidly in hair mortar and pointed in cement mortar, and gradually tilt them up towards the gable ends. Fill in open ends with plain tiles in cement.

(*To be Continued.*)

OTHER HOUSING SCHEMES.

In the following pages we give some brief notes of other housing schemes at present in progress.

COTTAGES AT SUNDON.

It will be recollected that in a previous issue we referred to an experimental building scheme which the Luton Rural District Council were undertaking in the form of twenty-four cottages built in concrete. Although not yet completed the work is well in hand, and by the courtesy of the surveyor to the Council, Mr. Harold Picking, we are able to give some short particulars of these cottages, together with plans and elevation.

As will be seen from an examination of the plans the accommodation of each cottage comprises on the ground floor living room, scullery, larder, bathroom, and store, and three bedrooms on the first floor.

As to the construction, the walls consist of inner and outer blocks, 3½ in. thick, with 2-in. cavity.

The first floors consist of wedge-shaped reinforced concrete beams between which are placed hollow concrete slabs and the surface floated with a coating of plastic concrete.

Similar construction is adopted for the ceilings.

The roof trusses are of concrete and are made in halves for facility in erecting, and when placed in position are bolted together.

The principal rafters carry a large number of small purlins, so spaced that each purlin supports a row of specially made concrete tiles.

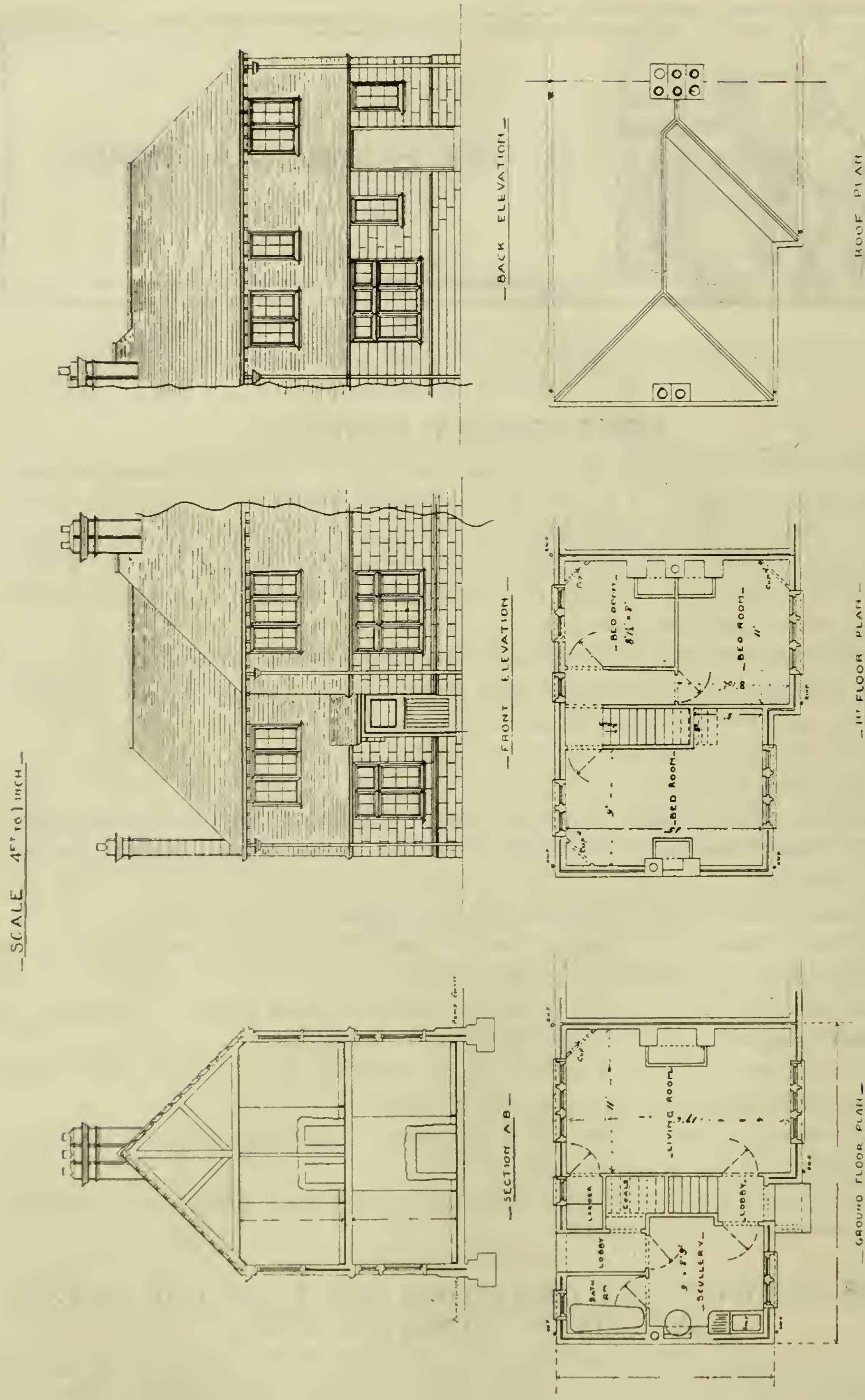
The window frames and sashes are of concrete, as is the staircase. There are detached earth closet and barn to each cottage.

The price per cottage, including drainage, water supply, roads, paths and fencing, will work out at about £395.

We hope at a later date to publish some further particulars and photographs of these cottages when completed.

SOME COTTAGES AT HERTFORD BUILT ON THE CAT-AR SYSTEM OF CONSTRUCTION.

The accompanying illustrations show two of the first houses to be erected at Hertford on the Cat-Ar system of concrete construction. The two houses are under one roof, the dimensions being 35 ft. by 30 ft. *Fig.* No. 1 shows the structure seven days after laying the first block. *Fig.* No. 2 shows the building 21 days later.



DETAILS OF LUTON COTTAGES.

These structures are erected on the principle of a pure parabolic arch. They are built of breeze or ballast concrete blocks, size 24 in. by 9 in. The roof is 4 in. thick, and the end walls formed of 3 in. and 4 in. blocks with a 2 in. cavity. The blocks are cast with grooves into which a continuous reinforcement of expanded metal is bedded. The concrete is mixed in the proportion of 6 : 1.

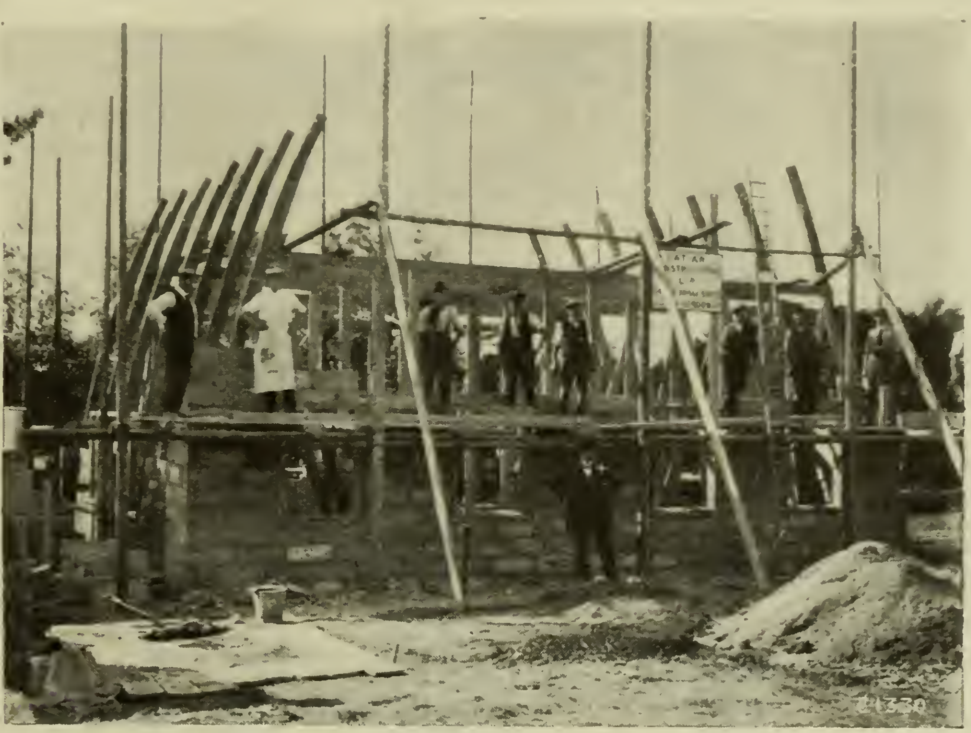


FIG. 1. STATE OF BUILDING 7 DAYS AFTER LAYING FIRST BLOCK.

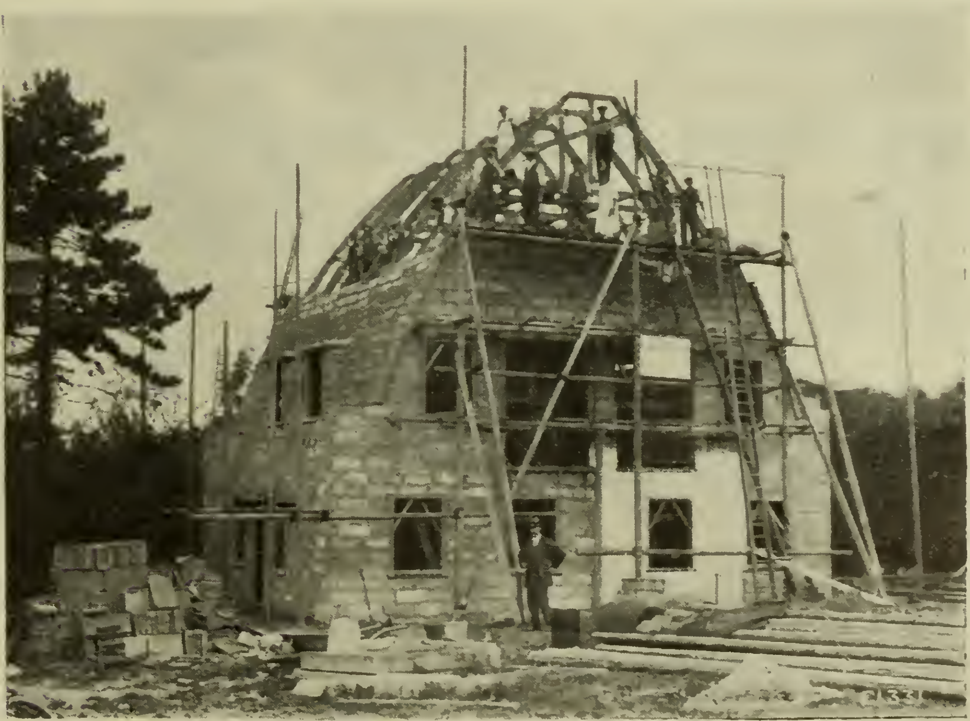


FIG. 2. 28 DAYS AFTER LAYING FIRST BLOCK.
COTTAGES AT HERTFORD.

The construction is said to be so simple that any bricklayer can build the blockwork. Special care is taken with foundations to prevent the arch spreading, and sufficient strength is provided to resist crushing. By the insertion of the reinforcement sufficient adhesion is obtained between the blocks to resist the tendency to slide.

The keystone, or what may be termed the voussoir, in the crown of the arch, is constructed of reinforced concrete. The whole of the blockwork is scientifically treated to render the buildings damp-proof. The rooms internally are finished with vertical walls, thus forming air-chambers at the sides of the buildings, with a view to making the buildings warm in the winter and cool in the summer. The external walls are finished with rough-cast cementwork, and may be architecturally treated in a large number of designs.

No timber is employed in the roofs and no rainwater pipes or gutters are used. The upper floors may be constructed of reinforced concrete or timber. In no case is any weight placed on the arch, all joists having their bearing on the end walls. Channels are formed in the ground at each side of the building to receive the rainwater, and gulleys are provided to carry away the rainwater, which is connected with the drainage in the usual manner.

We understand that it is possible to erect a small dwelling in about 35 days and that the cost is about 30 per cent. less than a brick-built structure, while the strength is quite 150 per cent. greater.

HOUSES AT CANADA PARK, BURNT OAK, EDGWARE.

THE following illustrations show some concrete houses now being erected at Canada Park, Edgware, the concrete for which has been specially treated with a metallic liquid.

These houses consist of a terrace of four, three floors high. The two end dwellings are carried up and finished with a parapet and flat roof, while the two middle houses are finished with a pitch roof, the third floor being a mansard. This arrangement secures a pleasant breaking-up of skyline without destroying the simplicity of effect. The front rooms on ground floor project slightly in front of the general line, being covered by a pent roof, which, like the main roof, is covered with plain red sand-faced tiles.

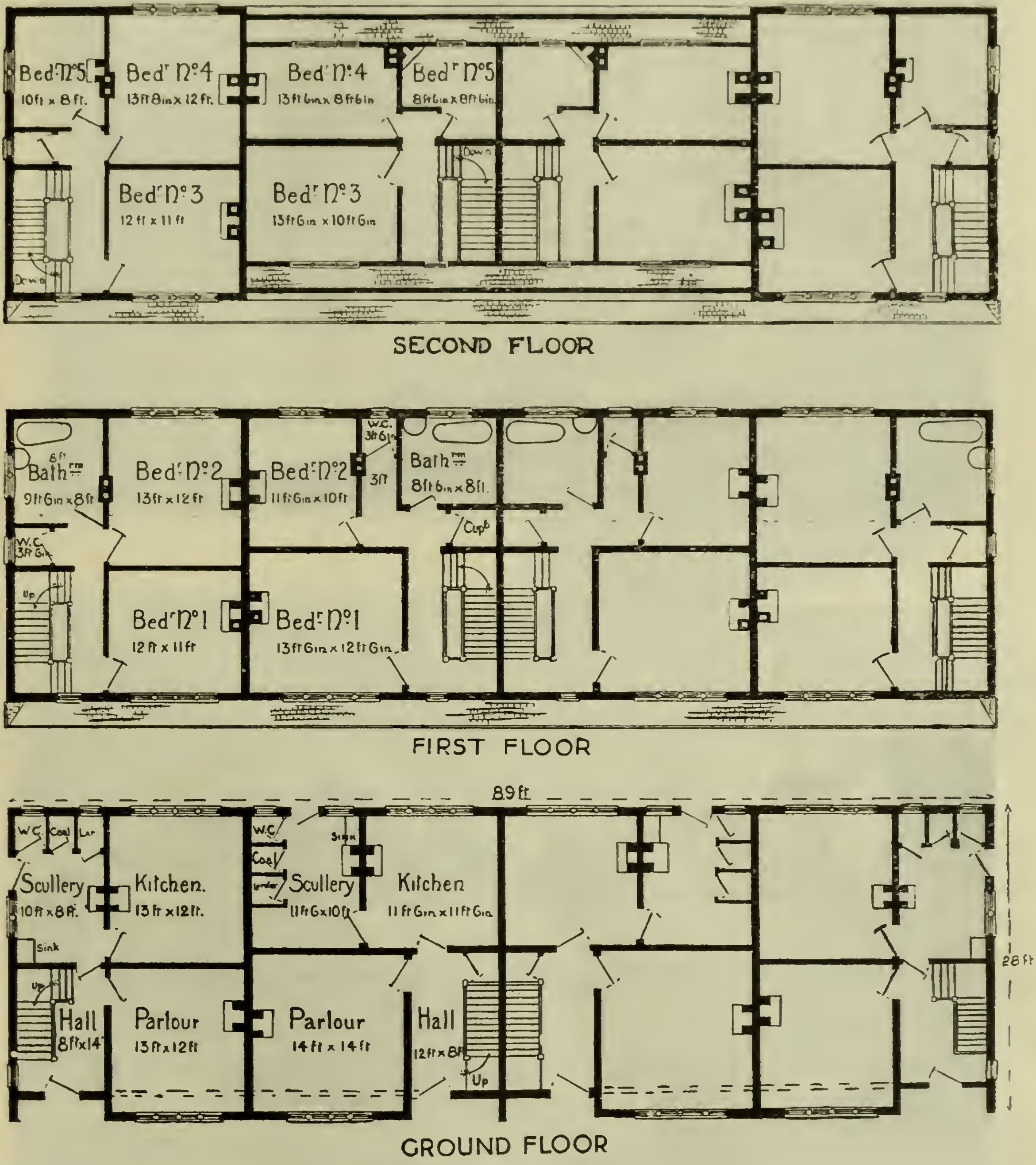
The plan is simple and direct, and comprises in each house two reception rooms, kitchen and scullery, etc., on ground floor ; two bedrooms and bathroom, etc., on first floor ; and three bedrooms on top floor.

As stated above the concrete for the blocks used here has been prepared in a special manner by the use of Lillington's metallic fluid. The method of procedure is as follows :—

Taking clinker as the aggregate to be used, the concrete should be composed of 1 of cement to 4 of clinker and 1 of sand, unless the clinker contains a larger proportion of "fines," when less sand can, of course, be used. After the cement and aggregate have been thoroughly dry mixed, the concrete should be knocked up with water and metallic liquid in the proportion of 5 of water to 1 of liquid.

The amount of moisture required per cubic yard of concrete is an important item, but it naturally varies considerably according to conditions—particularly the nature of the aggregate.

Sufficient moisture should be used to completely set the cement, but beyond this the mixture should be kept as dry as possible in order that the block may come away from the mould more readily.



SECOND FLOOR

FIRST FLOOR

GROUND FLOOR

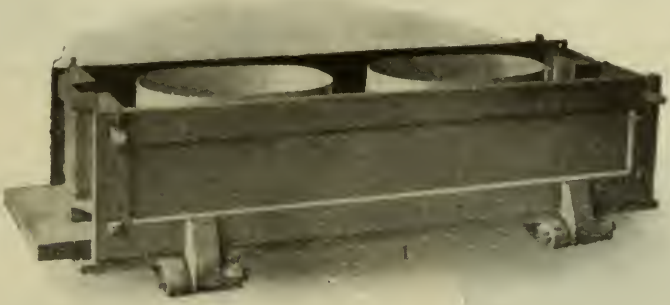
Plans of Houses at Canada Park Estate, Edgware.

The mould.—The mould for the blocks consists of an iron box 27 in. long, 9 in. wide, and 6 in. high, open at the top, and with hinged sides and detachable ends, the latter being held in position by iron pegs on chains. A groove at one end of the machine and a projection at the other provide the interlock. Loose oval cores form the two cavities, and a false wooden bottom enables the block to be removed from the mould and carried away to stack. These wooden bottoms are made with projecting pieces that form a longitudinal groove along the underside of block, a device to secure a perfect circulation of fresh air throughout the entire structure of the walls.

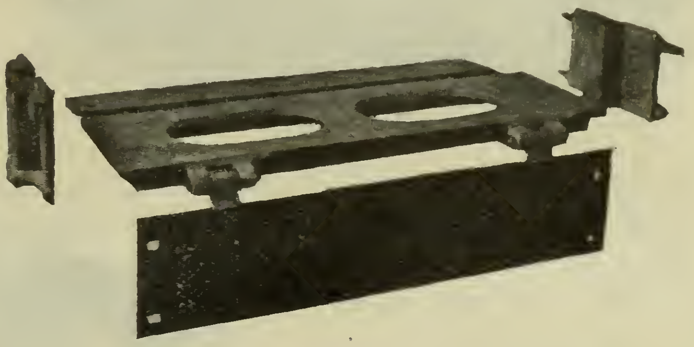
View showing the laying of the Blocks.

Elevation of Completed Houses.

The Making of the Hollow Block.—The concrete, which has already been carefully prepared, is now tipped into the moulds, tamped, rammed and trowelled off, the cores extracted and the sides let down when, after the ends have been removed, the block is carried away on its wooden bottom to the stack, the mould being again closed and again filled up. This operation of filling, tamping and stacking should only take about five minutes, and under reasonable conditions from 10 to 12 blocks per mould per hour should be possible.



A No. 1 Mould for ordinary Wall Blocks.



Mould showing Dropped Sides and Units.

It should here be noted that there are three types of moulds: No. 1, the ordinary hollow standard block; No. 2, the adjustable block, which, by a series of holes in each side enables a shorter block to be turned out or a casement groove, jamb or reveal to be obtained; and No. 3, for producing quoin blocks.

The stacking of the blocks is said to be expedited by the use of the metallic liquid, it being possible to turn over the blocks on to their sides within 24 hours and remove the false bottoms for further use. The blocks are then left to mature for a period of about 7 to 10 days, no attention being required, except in the case of very warm weather, when it is desirable to keep the stack a little moist.

The Laying of the Blocks.—For this work only a man and a mate are required, who should be able to do the equivalent of a day's brickwork in about 3 hours, effecting a saving, with the less amount of mortar and finishing required, of about 15 per cent. to 20 per cent.

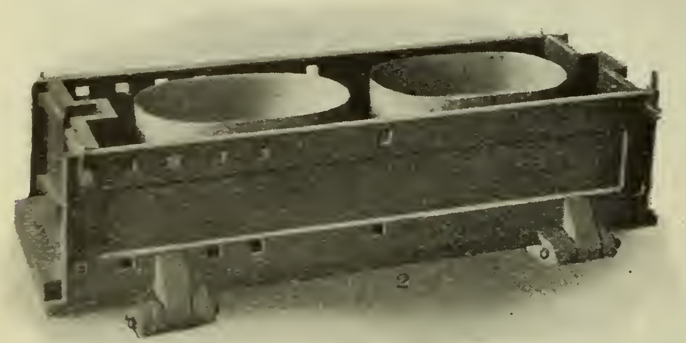
In connection with the houses here shown, we would mention that the damp course is on the Lillington principle, being composed of cement and granite chips and dust impregnated with No. 6 Metallic Liquid, in order to ensure an impervious layer, which at the same time sets hard and yet remains elastic. All lintels are in concrete suitably reinforced.

All internal partition-slabs are made in clinker and with metallic liquid. The upper floors are constructed of steel joists with clinker slabs, made on the site, let in between and resting on the flanges, the surface being filled up and floated off to form floor. This method avoids the expense, inconvenience and delay of shuttering.

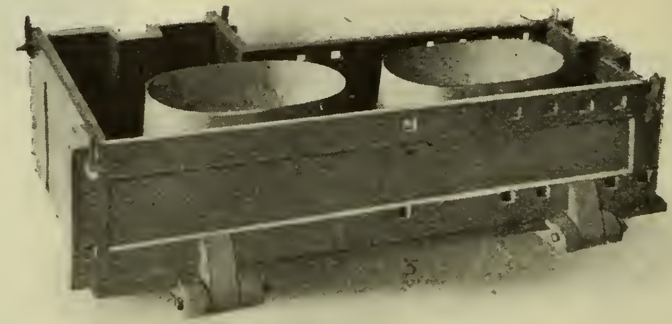
The flues are formed entirely of concrete, the necessary blocks being cast on the site.

The whole of the houses in this case are to be sand-faced with cement mastic made up with metallic liquid.

Those interested in the housing question should make a point of visiting Canada Park Estate, where they will be able to witness the whole of the operations above described.



No. 2. Mould fitted with Slots enabling the size of the Block to be reduced.



No. 3. Mould for Return or Angle Blocks—the insides are slotted so that the Block can be made to any Size required.

THE PROTECTION OF CONCRETE BUILDINGS AGAINST DAMP AND WATER.

The following is an article reproduced and translated from "La Revue des Materiaux de Construction et de Travaux Publics."—ED.

CONTRARY to general opinion, a concrete which is impervious to water is not necessarily impervious to damp. The chief causes of humidity in buildings are :—

(i) Damp foundations.

(ii) Dampness or water gaining access to the lower part of the building other than damp in the foundations.

(iii) Rain water beating against the walls of the buildings.

(iv) Faulty or negligent construction whereby water penetrates the walls.

(v) Sweating of the walls.

The ground both inside and around the structure should be made damp-proof and all access of surface water should be cut off. The walls should be built in such a manner that rain cannot be driven into them so as to reach the inside faces. A cavity wall is often superior to a solid one in this respect. The use of impervious water is also advisable.

The entrance of water through openings in the walls or at the eaves is chiefly the result of defective workmanship, but may usually be remedied by suitable treatment.

The sweating of walls on the inside of the structure is due to sudden changes in the internal and external temperatures, whereby warm, moist air is brought into contact with the cold concrete and condensation occurs. This may be prevented by interposing a protective material whose temperature is intermediate between that of the warm air and the cold wall, or by building the walls in such a manner that the temperature of the air in internal surface has no relation to that of their outer surface. Hollow blocks are recommended.

To prevent the unpleasant effects of dampness it is desirable to :—

(i) Apply superficial coats, such as paints, plaster or substances of a membranous nature to the damp portion.

(ii) To apply an integral method in which water or damp-proofing material is added to the concrete whilst the latter is being mixed and before the walls are built. The material may be added in solution or it may be mixed dry with the cement. The liquid agents are supposed to be uniformly mixed with the material, but the dry and finely powdered agent is usually the more convenient.

The possible action of the water-proofing agent on the reinforcement and on the concrete proper should also be ascertained at various temperatures so as to avoid corrosion. The following proportions are suggested where dampness or water is to be combated :—

(*a*) For four parts of crushed stones, ¼ to ½ in. diameter, a mixture of 1 part of cement and 2 parts of sand containing rather more fine grains than are needed to obtain a concrete of maximum strength—*i.e.*, a 1 : 2 : 4 mixture.

(*b*) For smaller stones (½ in. and less) a 1 : 1 : 2 mixture will give better results than a 1 : 2 : 4 concrete. Recent investigations have shown that natural gravel stone gives a more impervious concrete than one made with crushed stone.

For mortars for recovering façades a mixture of 1 part of cement to 3 parts of sand is excellent, whilst a 1 : 2 mixture is equally suitable for foundations.

Concrete is made more damp-proof by the addition of hydrated lime to each 100 lb. of cement used.

The use of coatings and plasters protects concrete against both dampness and water in large quantities and their decay is by no means rapid. They may be applied advantageously to surfaces above ground level or to the interior of tanks and other containers. They usually consist of solutions of soap and alum, coatings of tar or paraffin, cement slurry containing a waterproofing agent and applied in a series of layers.

Another group of superficial protecting agents includes elastic materials such as tar, asphalt, etc., which are applied hot, and sheets of felt. To be effective such materials must completely cover the surfaces to be protected, especially at the joints. When the pressure of a liquid is to be resisted, alternate layers of felt (either coated with tar or not) and of asphalt, or preparations with a tar base, are used, the number of coats varying with local conditions, one to six coats being applied (*Figs.* 1 and 2). A ¼-in. coat of cement mortar (1 : 2) may be applied as a finish. This method of waterproofing is preferably applied during the construction of the building.

In waterproofing foundations, a bed of impervious material should be laid to form the base, on which is placed a sheet of tarred felt which goes beyond the wall on each side. When the wall is complete and the setting of the concrete is certain, the sheet is folded up against the wall and attached by means of asphalt or tar. The outer side of the wall is then tarred from above downwards, and special care is taken to make good joints. In *Fig.* 1 sufficient space is left on both sides of the wall to enable the workmen to move about readily and to facilitate the application of the sheets. Where there is less space the arrangement shown in *Fig.* 3 may be used, the work being commenced by building a wall of brickwork, lining this on the inside with impermeable sheeting and then placing the concrete close to the latter.

When there is no cellar it is desirable to place sheet lead, bitumen or other composition between the walls of the foundations and those of the building proper to act as a damp course (see *Fig.* 4). It is necessary to ventilate the space between the foundation and the ground floor by means of protected openings in the foundations.

The following experiment is instructive : If one edge of a sheet of blotting paper is dipped in water the latter will raise up the paper, and if the latter is in contact it will soon be saturated. If a sheet of the same paper is wet and placed in a closed vessel with another (dry) sheet of blotting paper near to but not touching it, the dry sheet will be quickly dampened by the moisture from the first sheet. If, however, a current of air is allowed to circulate freely in the vessel the wet sheet will dry rapidly without the dry sheet being affected. A similar phenomenon is observed in buildings. Thus, if two parts of a solid wall are connected by a porous joint, any moisture in one part will be transmitted to the other through the joint. If two walls are separated by a closed space filled with stagnant air the moisture will tend to pass from one to the other, but if the cavity is properly ventilated the interior wall will remain dry. This does not mean that a system of ventilation is essential, but that the enclosed air must be sufficient to absorb and to retain all the moisture under all conditions.

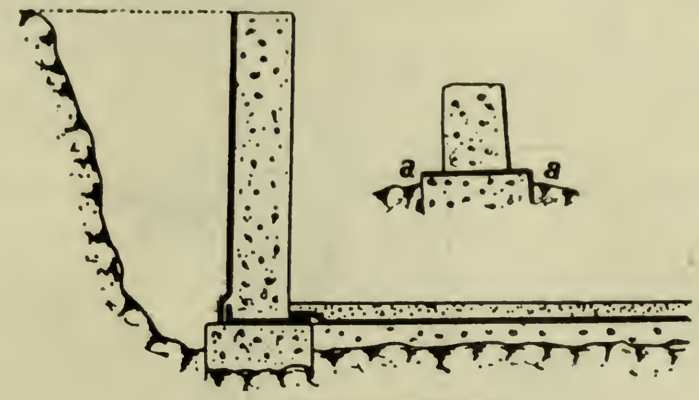


FIG. 1. Impermeable Sheeting.

When metal or other ties which are likely to be damaged by moisture are employed they should be covered with a plaster in order to preserve them.

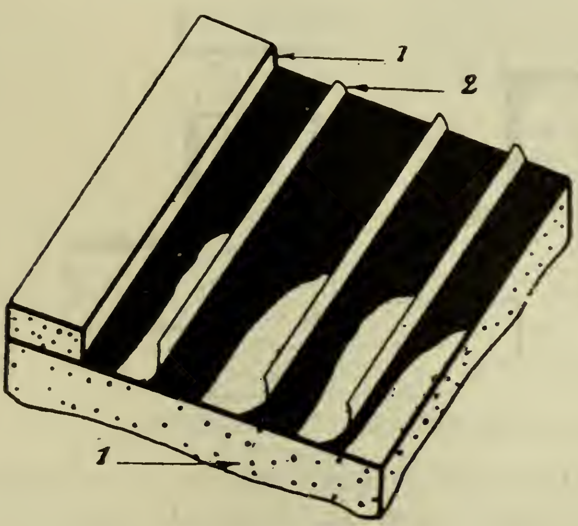


FIG. 2. 1. Concrete.
2. Layers of felt.
The black parts represent lac or bitumen.

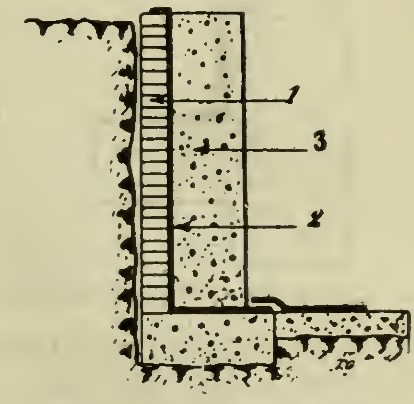


FIG. 3. 1. Wall of light bricks.
2. Impermeable sheeting.
3. Foundation wall of concrete.

Continuous wall-cavities are liable, in case of fire, to prove very dangerous, as they act as flues and increase the distance travelled by the flames. For this reason and because they are primarily used to prevent damp interiors such cavities should be broken into smaller ones, not open to the atmosphere.

When concrete paints are used as waterproofing agents it is imperative that the concrete should be quite dry. The various preparations of this character each have their special advantages—some preserve the outer surface of the concrete or prevent efflorescence. Others preserve the interior surfacs of the building. In either case all cracks should be filled before the paint is applied.

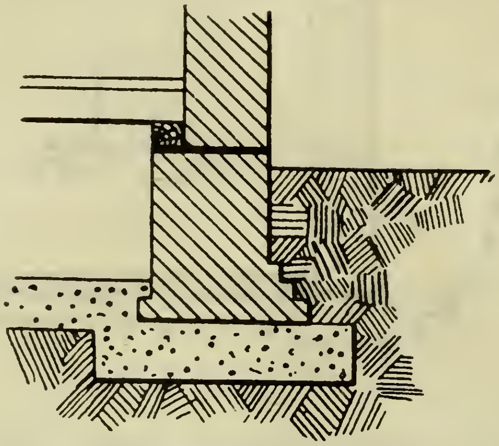


Fig 4.

A roof is waterproofed in the same manner as any other part of a building. If it is of concrete a good waterproofing agent such as tar, felt and asphalt, may be applied to either the apex or lower surface. The joints between the wall and certain other parts of the building such as chimney, skylights, etc., or between the latter and the roof should be made with special care. *Fig.* 5 shows three methods of making a good joint between a balcony projecting wall or chimney and the roof.

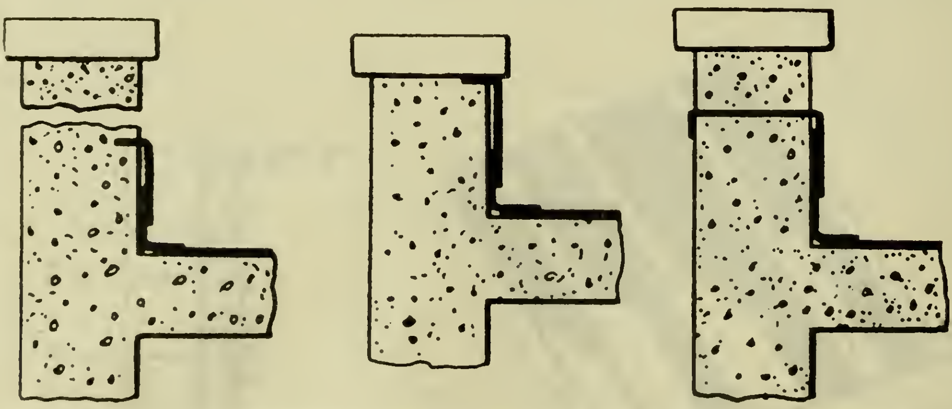


Fig. 5. Three ways of forming watertight joints between a cornice and a roof balustrade and a chimney.

If dampness penetrates through the space between window or door-frames and the walls, attention should be paid to such spaces, and if one of the applications previously mentioned is made with sufficient care it will usually prevent any further trouble.

BETTERING CONCRETE BY A NEW MIXING METHOD.

By NATHAN C. JOHNSON.

The following is an abstract from a lecture given by Mr. Nathan C. Johnson before the Philadelphia Engineers' Club. In his lecture Mr. Johnson adopted the method of showing a number of moving pictures to demonstrate the mixing and setting processes of concrete—(the use of moving pictures for the purposes of technical education is finding increasing favour in the United States and is a method by which we might probably do much useful work in this country). In the course of the lecture some attention is devoted to a new type of mixer for which it is claimed that the cement gets the needful thorough contact with the aggregate.—ED.

I.

Since the majority of the units entering into concrete are minute, they may be virtually affected in whole or in part by things minute, although collectively of great importance. It may even prove on examination that what to the eye are tiny crazings, of questionable import, may be vast chasms relative to the size of a cement grain put into the mass as a medium for transferring stress from sand grain to sand grain and that they may interpose impossible barriers to its functioning. Single air voids not uncommonly bulk larger than a dozen or more sand particles ; and air voids are known to be present in vast numbers. Water pockets by the thousands in a single yard of concrete may cut off certain other would-be workers by the hundreds of thousands, and even sizable stones.

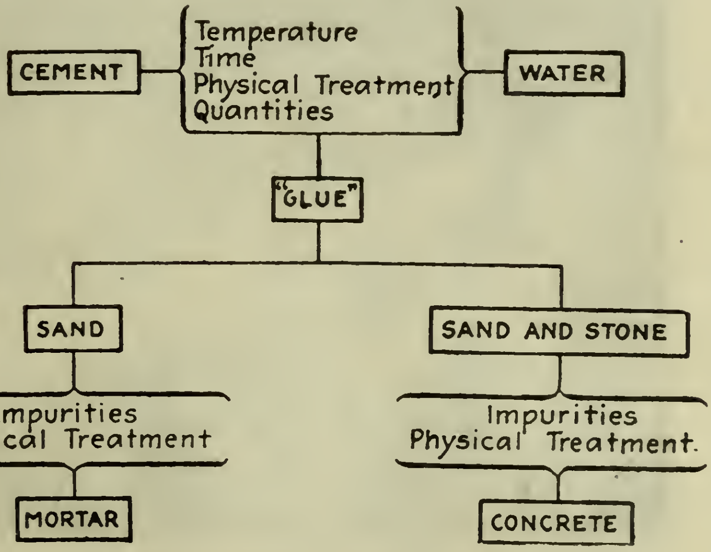
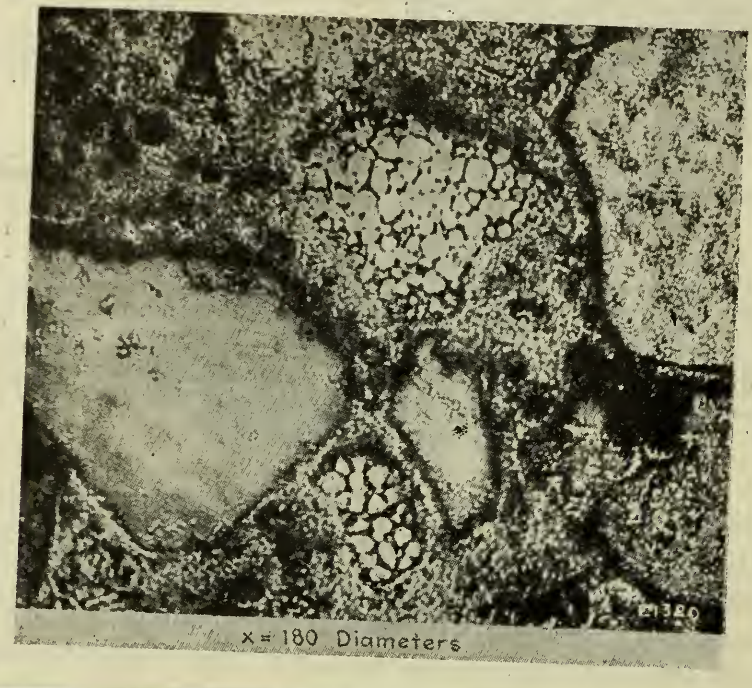


Fig. 1. Genealogical Chart of Concrete and Mortar.

To estimate the true significance of such possibilities it may be well to place in diagrammatic form, as a preface to deeper study, the family tree of concrete. (See *Fig.* 1.) First and foremost in importance is the "glue" formed by the union of the powdered cement of commerce with water. As this formation is a chemical reaction, it follows the laws of such reactions and is affected vitally by two variables, temperature and time. The first is particularly difficult of regulation in field operations, but the second—as well as a third variable, physical



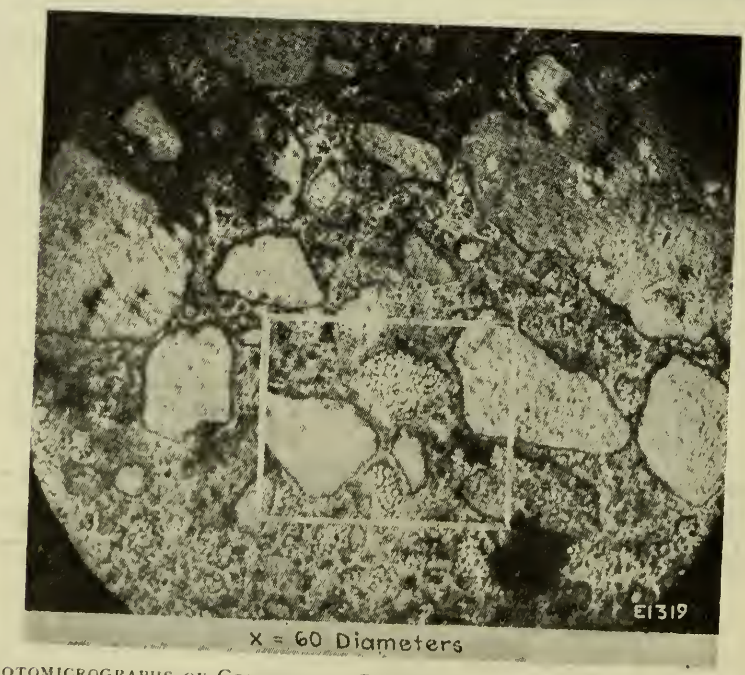


FIG. 2. PHOTOMICROGRAPHS OF COMMERCIAL CONCRETE SHOWING SAND GRAINS, UNUSED CEMENT AND AIR VOIDS.
The view above is an enlargement of the section limited by lines on the lower view.

treatment—may be controlled. Obviously, also, the strength of the fluid cementing solution so produced will depend primarily upon relative quantities of the two reacting substances. To the "glue" thus formed, which has greater or less worth according to the values of the variables affecting its formation, sand is added to make mortar, or sand and stone to make concrete—with, in each case, impurities, such as air, or other contaminating substances, and, again, physical treatment, entering as factors qualifying ultimate value.

If cement were supplied as ground after burning in kilns, it would be so hungry for water that reaction with mixing water would take place too quickly; and to avoid this, manufacturers add gypsum, which is hydrous or water-bearing calcium sulphate, to the still hot cement. This heat drives off water from the gypsum; and this water, spreading as steam, reacts with the hungry cement particles, forming over their surface a very thin, protecting skin of dead or hydrated cement, which for a time—depending upon the thickness of this skin and the temperature—resists penetration of mixing water to the active material within, deferring reaction to give ease in handling. It follows, therefore, that little of this chemical action has taken place before concrete is placed in forms.

Such a protective skin is pictured in the photomicrograph, *Fig.* 2, about an inert cement grain found in concrete. Obviously, it should be advantageous to remove this dead skin in some way when ready to use cement, so that water might find access without delay and make more and stronger "glue" in the brief hour or two of freedom before setting takes place. Of course, we must coat sand and stone with cement. Yet reason tells us that even an infinite supply of cement particles can cover a sand particle only so far as they may touch it at tangent points, while a solid bedment is assumed and desired in concrete. If there is not an infinite supply of cement particles, even this tangent covering is not possible.

Furthermore, when cement particles, sand particles and pieces of stone are wet, an envelope of water covers them, preventing contact, except accidentally, even at points of tangency, as shown in the diagram, *Fig.* 3, traced from the photograph, *Fig.* 2. This explains why there is rarely, if ever, contact between particles as their relative positions are revealed in magnified photographs.

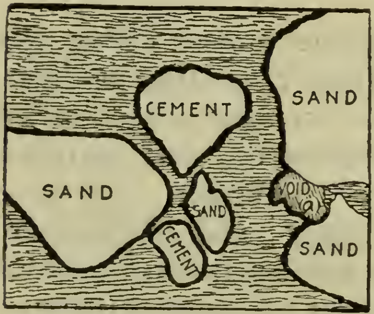


FIG. 3. PART OF FIG. 2

A little thought and calculation with regard to aggregates reveal certain other facts not often considered. Briefly, these are that in a cubic yard of 1 : 2 : 4 : concrete there are about one million stone particles, up to and including $1\frac{1}{2}$; that there are about 25 *billion* sand particles with a commercial coarse sand, or 200 billion particles with a very fine sand, all of which have to be distributed and wetted and mixed with some 200 to 300 billion cement particles in a space of time that will pay commercially—usually less than a minute. Evidently, since this is so, "covering" sand and stone with powdered cement would really mean that when using coarse sands there would be not to exceed four to six cement particles; and using fine sands, not to exceed 1 to $1\frac{1}{2}$ cement particles for each piece, large or small. Covering should be actual and thorough and uniform; but, obviously, true covering can only come through spreading of a liquid cementing product; and to achieve even a fair result, there must be left no analogue to the "unstirred sugar" of a cup of coffee, else some billions of potential workers will be rendered idle through denial of means wherewith to do their appointed share of work.

Remembering these things, further light may be gained by reconstructing the processes that formed a representative concrete, now in existence. Concrete from the warehouse of the Naumkeag Steam Cotton Co.'s warehouse at Lynn, Mass., is shown in *Fig.* 2, magnified 60 diameters. In it are clearly visible the sectioned sand grains with their irregular outlines ; the clear matrix of hydrated cement ; a few voids ; and some " unstirred sugar " in the form of unhydrated, cement particles. In *Fig.* 2 is also shown the lower centre of the same field, enlarged to 180 diameters. It is to be remembered that in each of these photographs the relative positions held by the several substances are the positions held by them when placed in forms and that must be held by them so long as the concrete endures. What happened when this relationship was first established ? All cement particles in the vicinity doubtless reacted with water rather quickly for some time after the protecting skin was pierced. During this interval the sand grains lay surrounded by water, waiting quietly whatever might happen, save, perhaps, for an occasional settlement to easier position as concrete deposited above increased the general pressure.

At the surface of cement particles, however, there was, at first, saturation of the hydrated skin ; then spasmodic reactions as water first reached active cement, formed new products, became sated and gradually diffused ; then renewed activity as new water reached deeper layers of active cement through the same agencies, with repetition of the processes until setting of the richest products *directly at the surfaces of the cement particles* formed a new protective skin and brought about a shut-down of hydration.

The water-filled space about cement and sand particles was, during this time, gradually becoming charged by diffusion with these cementing products. But, diffusion is slow ; and as distance from the source increased, concentration of these products became less, being *least* at the surface of the sand particles, where for man's purposes it should have been *greatest.* If diffusion could have been aided by stirring, this defect would have been overcome ; and, furthermore, longer activity of the cement particles would have been possible through removal of those surcharged products at its surface (where richness was not desired) and supplying of fresh water. Surely, one way of improving concrete should lie in procuring by some means a greater concentration of cementing products and distributing these, instead of insulating and diluting water, over the sand and stone *before* they find their final position in forms. If this were done, " water voids "—spaces left by water uncharged with cementing products—would disappear, for there would then be no uncharged water, and the nature of such charging products is to solidify.

One other feature is prominent in these photographs—namely, an air void (recognised by its spherical or spheroidal form) tucked away at a surface pocket in a sand grain. When this grain was first wetted, this pocket was, of course, filled with air ; and before the air could escape the vicious water envelope went over it, imprisoning it by surface tension ; and, as diffusion progressed, moulding it for all time in solidified cement.

By optical examination, boulders and sand grains of all sizes are found to have similar surfaces, full of pits and seams which are admirable for attachment of cement if contact could be brought about, but potent for ill unless inclusion of air bells is prevented. If only some means, such as stirring or scrubbing, could be utilised to remove impurities such as air, considerable improvement in general quality should result, for although one void is very minute, its duplication billions of times must be of great importance.

Although the mind sees in increasing number other possibilities indicated by reasoning as probable means of bettering concrete, those cited have every element necessary for very substantial improvement, provided they can be put into effect.

(*To be continued.*)

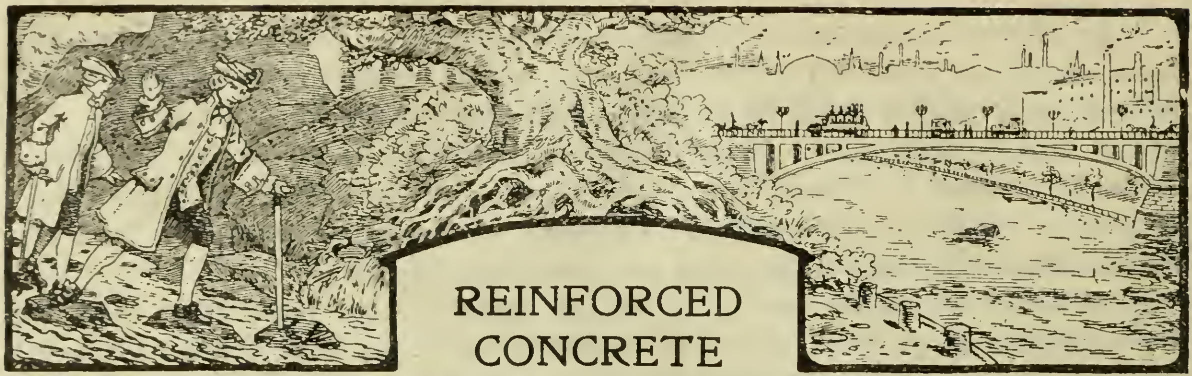
MEMORANDUM.

The Concrete Institute and the s.s. " Faith."—By the courtesy of Messrs. Richards, Longstaff & Co., the agents for the owners of s.s. *Faith*, now in dock at Canada Yard, Surrey Commercial Docsk, some members and other representatives of the Concrete Institute were enabled to inspect this reinforced concrete boat on September 9th, and their interest was greatly stimulated by the enthusiasm of Captain Campbell, who has just brought her across the Atlantic at the comfortable rate of 7½ knots ; the boat could manage its 10 knots all right if so required, but the former speed is regarded as adequate, for it must be remembered that the *Faith* is a cargo boat and not for passengers. The captain, however, declares that it would prove much more attractive to passengers than the average ocean-going steamer, as there is no game of pitch-and-toss takes place on his boat when crossing the briny. The length is 336 ft., the width is 46 ft., and greatest depth is some 25 ft., with an average draught of about 22 ft. ; its tonnage is 3,070 ; it is built with four bulkhead tanks, each being constructed (as is the whole shell) of reinforced concrete. The oil and fresh-water tanks are all bulkheaded off also. The *Faith* is a single-screw vessel and has duplicate engine installations ; it possesses a large steerage room, and should the mechanical steerage by any chance break down the boat can be hand-steered.

The boat is normally worked by electricity, but it can alternatively be worked by steam or hand, if occasion requires. There are two dynamos and an installation of twenty accumulators. The wireless installation can project messages for 200 miles, but the boat can receive messages from a distance of 1,000 miles. Anti-fouling paint has been employed as a surface finish. But, talking of surface finish, a reference should be made to the highly decorative effect of the Captain's own quarters, forming a most attractive little suite, the wood used throughout being Californian redwood.

The boat accomplished the passage in nineteen days, but as time progresses and these reinforced concrete vessels are made more capacious and more powerful we shall find this speed greatly exceeded ; already one of these boats, of 8,000 tons capacity, has been launched over at New York, and will presently be careering across the pond. Though Captain Campbell (whose home is in Massachusetts) has not encountered heavy weather with this boat, yet it has been tracked by an 80-mile gale and only listed some 12 degrees, and in a 60-mile breeze this has not exceeded 2 degrees. Finally, the Captain said that in all his thirty-five years' experience of " life on the ocean wave " he has not met with any boat to equal this one.

The President of the Concrete Institute (Mr. N. D. Searles-Wood) expressed to the Captain the thanks of the party for his courtesy. Those present included also Sir Henry Tanner, C.B. (Chairman of the R.C. Ships' Sub-committee), Prof. Henry Adams (Past-President), and Messrs. Bamber, Bennion, Fylander, Colvill (representing the Board of Trade on the Sub-committee), Davey, H. J. Deane, Fowling (representing Lloyds Register of Shipping), P. M. Fraser, Lee, Noton, Petrie, A. Alban Scott, Shore, Stanger, Taylor, Theobald and Yeatman, together with the secretary of the Institute, Captain P. L. Marks.



REINFORCED CONCRETE RAILWAY PLATFORM.

The following illustrations and brief details refer to a railway platform erected during the war for a large motor company.—ED.

The platform shown in our illustrations was erected during the war at Longbridge Halt, near Birmingham, for the Austin Motor Co., Ltd., in accordance with the requirements, and under the supervision of their architect, Mr. Harrison. This platform, which was constructed in record time, was urgently required for the purpose of accelerating the entraining and detraining of several thousand operatives of the Austin Motor Co. Reinforced concrete was adopted in this case on account of its economy and rapid construction, taking into consideration the fact that the platform had to be erected on a rather awkward embankment.

The detail plans for the reinforced concrete work were supplied by Messrs. Edmond Coignet, Ltd., of Westminster. The reinforcement was composed of round bars of shell discard steel, bent and arranged in accordance with the above system, the principal feature of which consists in tying all the bars in the slabs, beams and pillars by means of annealed wire, so that none can get out of position during the concreting operations.

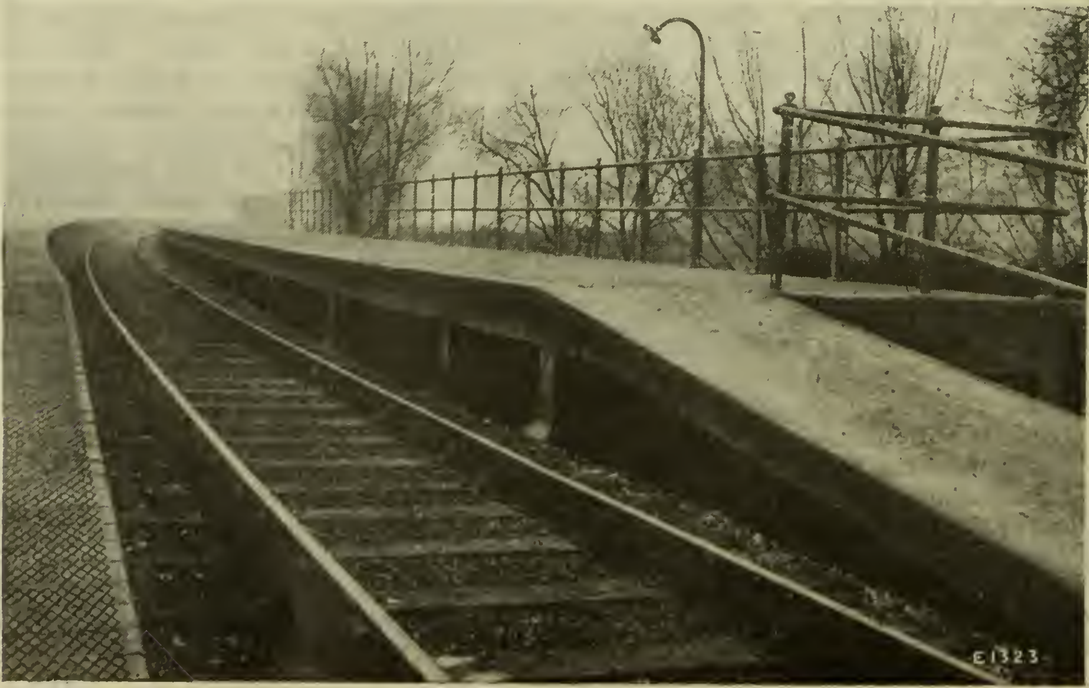


Fig. 1. View of Platform from railway side.

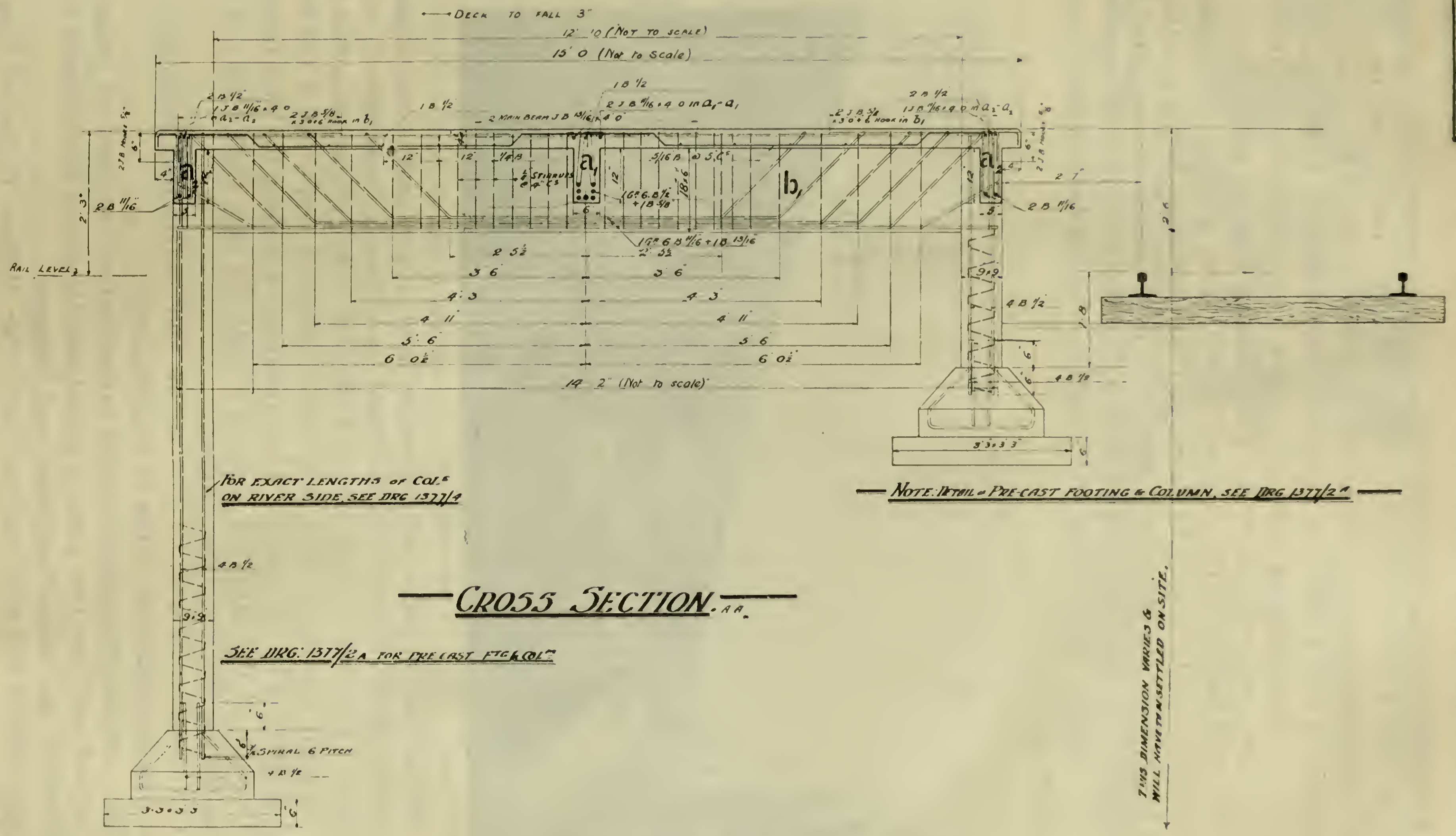

DECK TO FALL 3"
12' 10 (NOT TO SCALE)
15' 0 (Not to Scale)
2 B ½"
1 J B 11/16 × 4 0 in a2 - a2
2 J B 5/8 × 3 0 + 6 hook in b1
1 B ½
2 MAIN BEAM J B 13/16 × 4 0
1 B ½
2 J B 11/16 × 4 0 in a1 - a1
2 J B 5/8 × 3 0 + 6 hook in b1
2 B ½
1 J B 11/16 × 4 0 in a2 - a2
2 J B hook 5/8
6"
4"
2' 3"
2 B 11/16
a2
12"
12"
¼ B
¼ Stirrups @ 4" C/S
a1
12
16" 6 B ½ + 1 B 5/8
5/16 B @ 5 C/S
18 6
b1
a2
12
2' 7"
2 B 11/16
6"
RAIL LEVEL
16" 6 B 11/16 + 1 B 13/16
2 5½
2' 5½
3 6
3 6
4 3
4 3
4 11
4 11
5 6
5 6
6 0½
6 0½
14 2" (Not to scale)
9 9
4 B ½
1 8
9 2
4 B ½
3' 3 × 3' 3
6
FOR EXACT LENGTHS OF COLS ON RIVER SIDE, SEE DRG 1377/4
4 B ½
9 9
SEE DRG: 1377/2A FOR PRE CAST FTG & COL.
6
¼ SPIRAL 6 PITCH
4 B ½
3·3 × 3·3
6
NOTE: DETAIL OF PRE-CAST FOOTING & COLUMN, SEE DRG 1377/2A
THIS DIMENSION VARIES & WILL HAVE TO BE SETTLED ON SITE.
CROSS SECTION. A A.

Fig. 2. Showing details of Reinforcement.
A REINFORCERD CONCRETE RAILWAY PLATFORM.

As indicated in the illustrations, the platform, which has a total length of 762 ft., and a width of 15 ft., is supported on the railway side by means of short pillars and footings resting on the embankment, on the outside edge by means of a row of pillars of an average height of about 12 ft. A certain number of the footings of these pillars had to be constructed in the bed of an existing brook running more or less parallel with the embankment.

The total length of the platform, which forms a curve, was divided up into bays of 15 ft. long by 15 ft. wide. Principal beams having scantlings of 18 in. by 6 in. are placed in a transverse position and are supported by the pillars. The deck slabs, which have a thickness of 4½ in., are supported by the principal beams and by secondary longitudinal beams having scantlings of 12 in. by 6 in.

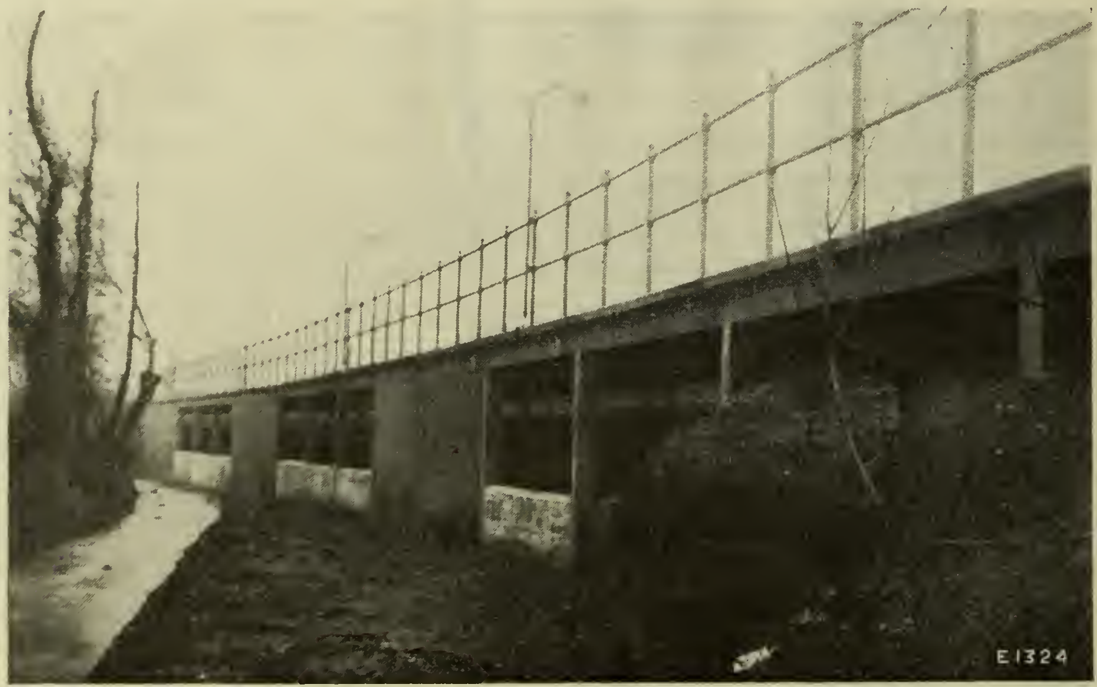


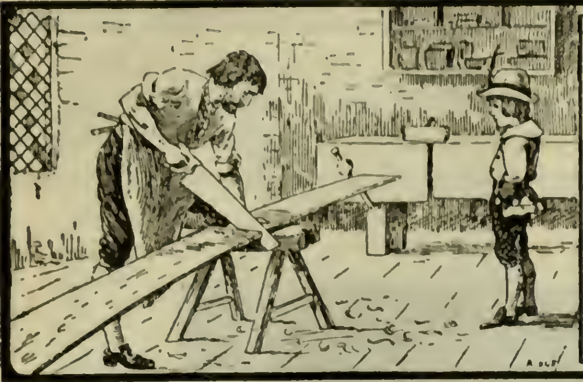
Fig. 3. View showing pillars on outside edge of platform.

The bars in the beams were arranged in groups of seven—one straight bar, and six others having their ends bent up and spaced gradually to take the shear. The end of each bar is hooked to a longitudinal top bar in order to form a complete unit, prepared in advance, and slung in the box centring ready to be concreted. The advantage of making the steel frames in units with all the bars tied together is that the bars cannot get out of position during the concreting process.

The pillars are all 9 in. by 9 in. square, and contain four vertical bars bound together by means of ties of small diameter.

The concrete was mixed in the proportion of one part of cement, two parts of sand, and four parts of gravel, and the top of the platform was made smooth and covered with sand and bitumen.

The whole of the work was executed by Mr. William Bishop, of King's Heath, Birmingham.



CONCRETE RAILWAY SLEEPERS.

We are indebted to the "Railway Gazette" for the illustration shown on page 592.—ED.

THE advantages of concrete for use on the railway have often been pointed out in the pages of this journal, and examples of its utility in this direction have frequently been described and illustrated. The growing shortage and increasing cost of timber and the soaring prices of steel and iron have led the railway companies to turn their attention more than ever to concrete as a substitute for these materials, and the fact that engineering departments of the principal railway companies in this country have established their own concrete yards, and that not far short of two hundred different articles and structures are now being made in concrete in these establishments, are proof that the claims of concrete for railway purposes which we have so persistently urged have not been exaggerated.

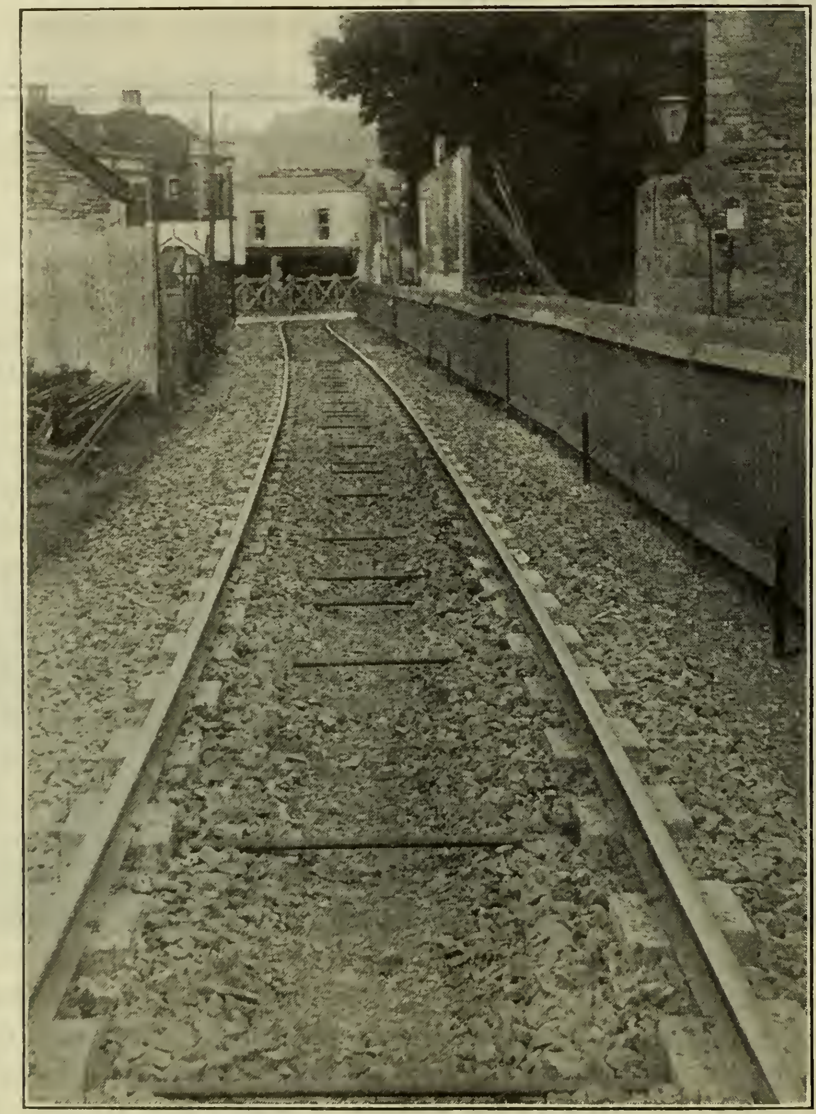
Of all the problems which have engaged the attention of the railway engineer in search of a substitute for timber, that of the production of the ideal concrete sleeper has perhaps been the most interesting, and, possibly, the most important. This product, in its present stage of development, has been shown to be perfectly satisfactory for light railways, branch lines, sidings and railways in connection with industrial works, but in a few instances certain railway companies, more courageous than the rest, have given the concrete sleeper a trial on their main lines, with, we believe, eminently satisfactory results, and the opinion of competent railway engineers is that the general adoption of concrete sleepers, apart from any timber shortage, is only a matter of time. The object of the present article is to give another example of the use of the concrete sleeper on light railways.

Lieut.-Col. Stephens, R.E., to whom we are indebted for the following particulars, is associated with many railways in this country, and, having been convinced of the utility of concrete for railway sleepers, has adopted this form of construction on the Weston, Clevedon and Portishead Light Railway. So far some three or four hundred yards have been laid down and have proved entirely satisfactory, although frequently subjected to speeds up to 30 miles per hour. The work is still proceeding, and the stretch of line with concrete sleepers is continually extending.

The type of sleeper adopted by Col. Stephens is that of the pair of concrete blocks tied by a metal bar, which is in this case a length of signal rod. The tie-bar is not used with every pair of blocks, but four or more, according to curvature and other circumstances, are provided for each 30 ft. rail. This is shown in the illustration.

The blocks themselves, when supporting 65-lb. flat-bottomed rails, are 20 in. by 12 in. by 6 in., and are spaced 2 ft. 2 in. apart. When employed for 80-lb. rails two additional blocks are used for each 30-ft. length. The maximum load per axle provided for is 14 tons for the 65-lb. rails and 18 tons for the 80-lb. rails.

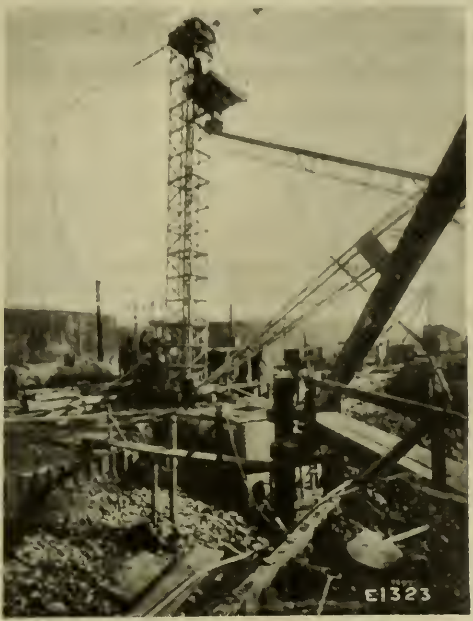
No chairs are used, but holes are cast in the block in which trenails are fitted for the reception of dogs or fangbolts.



Concrete Railway Sleepers on the Weston, Clevedon and Portishead Light Railway.

The blocks are not reinforced, and the moulds in which they are cast are very simply constructed. Unskilled labour under skilled supervision can be employed in the operation of concreting, which, we are informed by Col. Stephens, is confined to days when, owing to climatic conditions, outdoor work is not possible.

We learn that 1 ton of cement will make 86 blocks of the size in use on this railway.

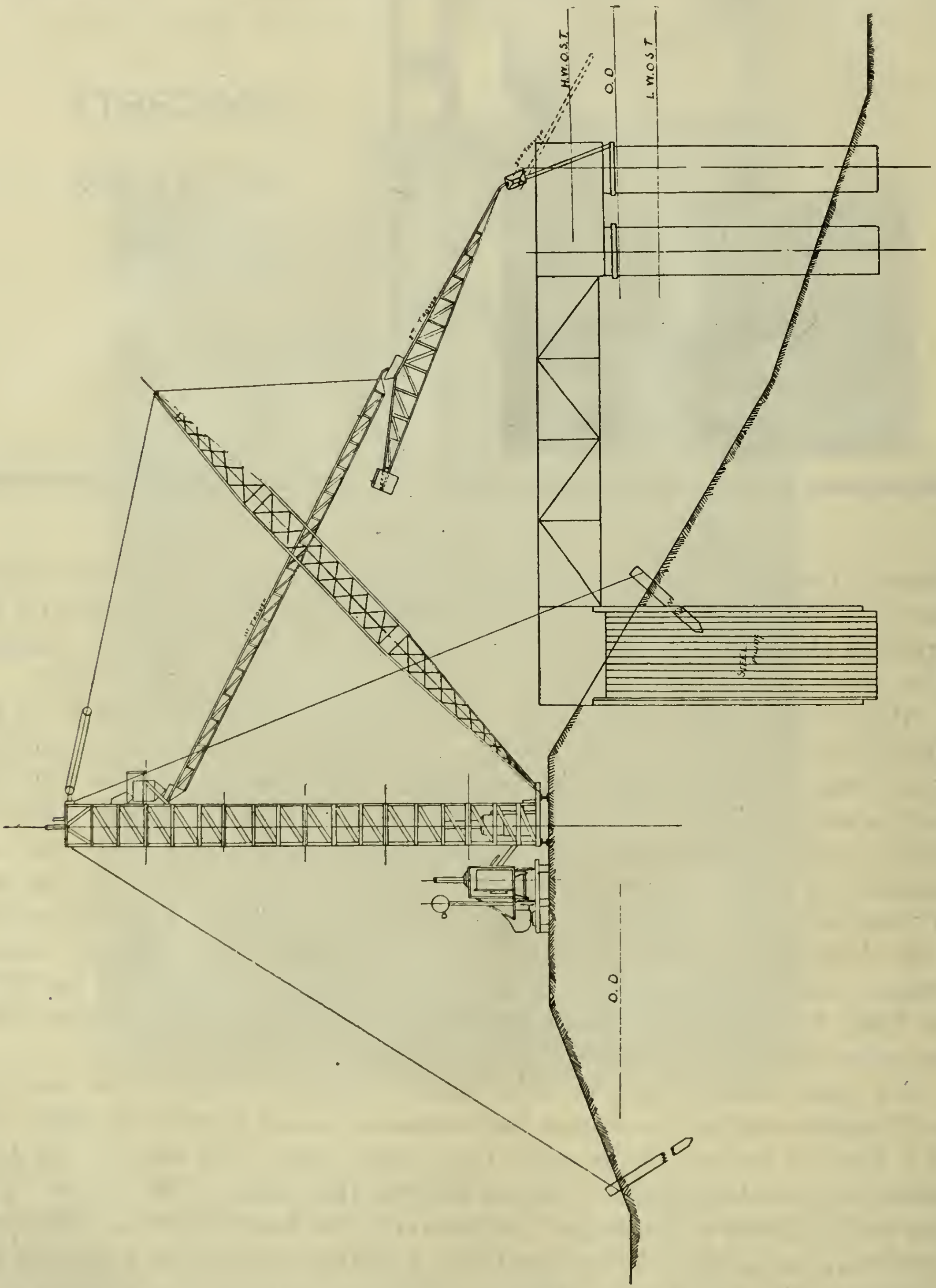


CONCRETE SPOUTING PLANT.

THE use of troughs arranged for placing concrete over a considerable area, although common in the United States of America and Canada, has not apparently been adopted in this country until recently, when the Admiralty scheme for pumping oil fuel across Scotland from the Clyde to the Forth was being carried out.

At the Clyde end of the pipe line a double row of columns had to be built in the river to carry landing stages for the tank steamers, these columns consisting of steel plate cylinders filled with concrete. When the question of filling the cylinders and placing the concrete for the flooring of the stages was under discussion, it was suggested that the most expeditious method, and the one most economical in man power, would be for the concrete to be mixed on the shore and conveyed to the cylinders and stages by troughs. This proposal was adopted by the Admiralty engineer, and the work was entrusted by Messrs. Morrison & Mason, Ltd., the contractors for the Clyde oil fuel installation, to the British Steel Piling Co., who had supplied the sheet piling and pile driving plant for the river embankment at this depot.

The plant consists of a concrete mixer with side loader, from which the mixed concrete falls into a skip at the bottom of a steel tower 72 ft. high. The skip is lifted to the top of the tower by a steam winch, and when at the top is automatically discharged into a hopper fixed on the outside of the tower. From a gate at the bottom of this hopper the concrete is discharged into the first trough, the gate being arranged to be operated from a platform around the hopper or from the ground. The first trough, which is 72 ft. long, is carried by a lattice girder and discharges into a second trough 32 ft. long, this trough being carried on a girder provided with a balance box to afford means of easily fixing the girder and trough at any angle required for the work. From the end of the second trough a third trough 24 ft. long is suspended by a universal joint allowing the trough to swing a complete circle horizontally, and also providing all the necessary movement in a vertical plant to suit any angle at which the trough may require to be used. A similar universal joint is provided at the junction of the first and second troughs. The weight of the troughs and their contents is carried by a steel lattice jib, 80 ft. centres pivoted to the base of the tower and provided with wire rope luffing tackle, the luffing gear being worked from the winch. The jib is designed to slew through an angle of 90 degrees and the troughs are suspended from the jib by wire rope blocks, which provide for raising and lowering the

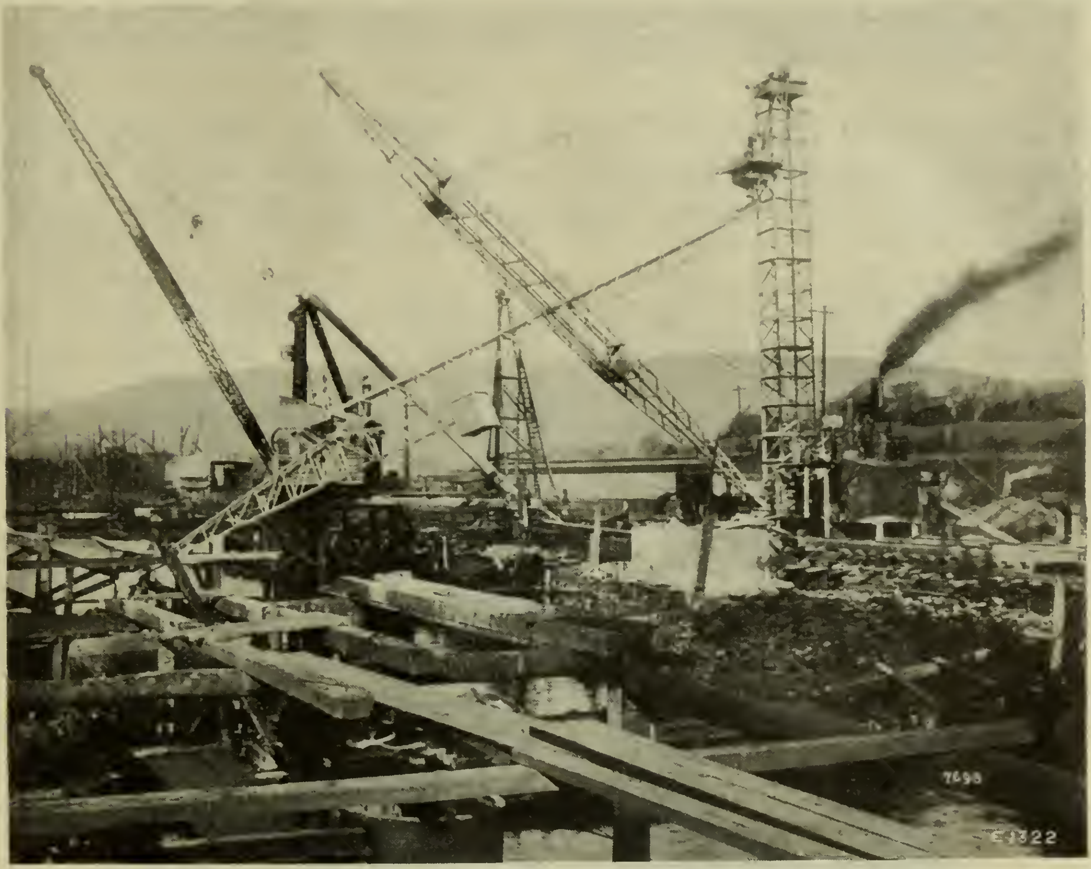


General Arrangement of Plant.

troughs as required. The photograph shows the plant as used for the nearer row of cylinders, for which case the third trough has been removed, two troughs giving sufficient reach for this portion of the work.

The maximum radius of the plant is 112 ft. Travelling wheels are provided to enable the tower to be moved into another position when required.

The whole of the plant was designed by the British Steel Piling Co., of Dock House, Billiter Street, London, and the manufacture was carried out at their Greenwich Works, where they have just completed another plant in which the tower is 104 ft. high and the radius reached by the troughs 140 ft., this plant being designed to place the concrete for a large seven-storied building in the Glasgow district. In any case, where 2,000 or more yards of concrete have to be placed in a fairly compact area the use of a plant of this type is worth consideration. In very large jobs the saving effected approaches comparison between that involved by conveying a large quantity of water through a pipe line as against transporting it in movable vessels.

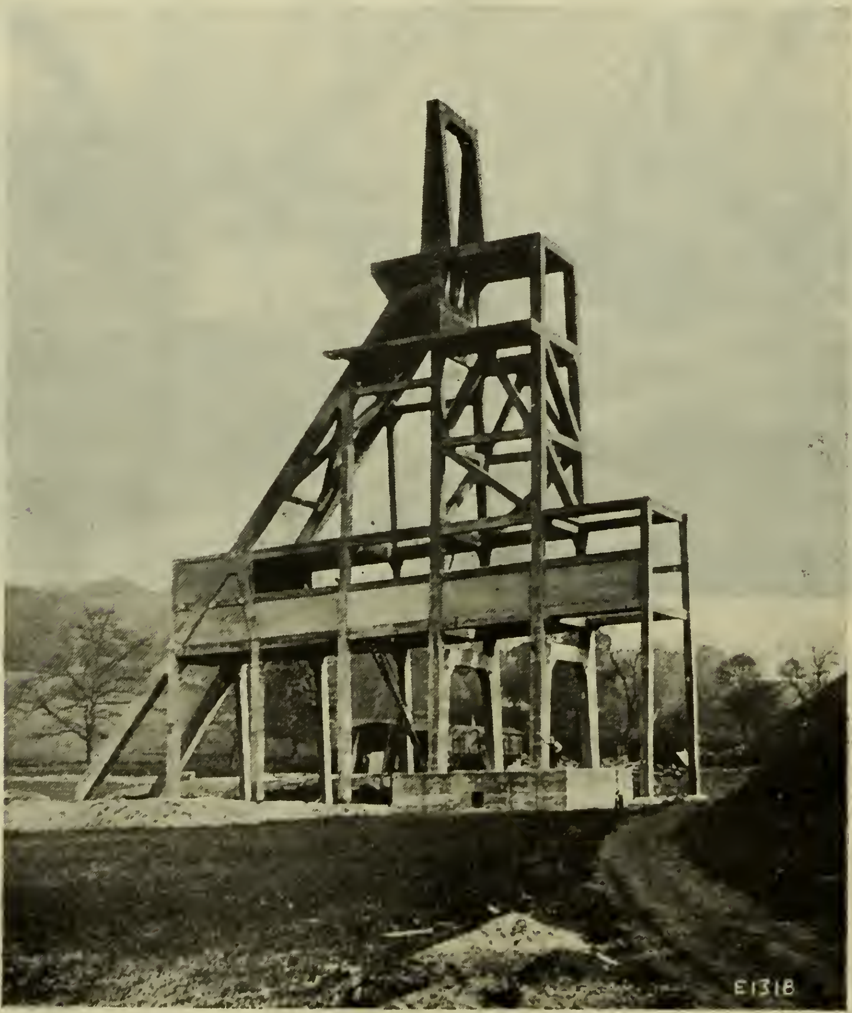


With the ever extending use of concrete there can be little doubt that the placing of concrete by suitably arranged troughs (sometimes called spouting plants) will become a regular feature on all jobs of any magnitude.

Concrete Headgear Frame at Lochore, Fifeshire.

We give below a few particulars with illustration of an interesting piece of work relating to colliery work, and which we understand is the first of its kind in Scotland to be entirely constructed of reinforced concrete.—ED.

THE advantages of the use of concrete for colliery and mine work, both for underground and overhead structures, has been repeatedly referred to in these pages, especially with a view to minimising fire risks. The timber shortage is leading colliery owners to give more attention to the use of other building materials, and in the near future we may look forward to seeing a far greater use



made of concrete, not only for surface work, but underground, for building, haulage, engine houses, and for protecting main roadways.

The headgear frame of which we give an illustration herewith was erected recently at the Mary pit, Lochore, Fifeshire, for the Fife Coal Company, Ltd.

Briefly described, the structure is entirely of reinforced concrete, carried out on the Kahn system. The foundation for the shaft tower is in the form of a reinforced concrete raft, 41 ft. square and 4 ft. thick, and from the back of which run out two 5 ft. by 3 ft. ground beams for a distance of about 70 ft., terminating and connected with a solid concrete angled foundation slab, from which spring the back or lying legs of the structure running right up to the top platform at pulley level. On top of the abovementioned raft there is a super foundation 30 ft. square and 7 ft. deep, the surface of which is ground level, and upon this the four main columns surrounding the shaft are set, being monolithically connected to the foundation, these columns going right to the pulley platform, being connected at intervals by horizontal beams and angled braces as shown on the photos. At 26 ft. above ground level there is a reinforced concrete decking with provision made for lines of rails, this decking being for receiving and discharging the coal hutches as they come off and are put on the cages. Above decking; at a further height of 14 ft. a reinforced concrete roof has been formed, and the space all round between decking and roof has been enclosed, the lower half with patent Hy-rib steel mesh, cement rendered inside and outside forming a wall about 2 in. thick, and the upper being glazed, the whole forming an enclosed housing.

The height of this reinforced concrete headgear frame is 90 ft. 3 in. from ground level to centre line of pulleys; while the total overall height from foundation level to top of standard on head of frame is 126 ft. 3 in. There is a concrete platform at top measuring about 30 ft. by 16 ft., giving ample accommodation for carrying out any work at the head of frame.

The whole structure has been designed on very liberal lines, giving great strength and stability.

The contractors for the work were Messrs. Clark & Chapman, Aberdeen.

MEMORANDUM.

A Concrete Bridge.—A concrete bridge nearly a mile long is to be constructed across Mohawk River and Barge Canal. The plans for this bridge had been prepared prior to the Americans entering the war, and the work was temporarily suspended. The bridge is to be known as the Great Western Gateway, and has a total length of 4,486 ft., comprising twenty-three spans ranging from 106 ft. to 120 ft., and one 212 ft. span over the Barge Canal channel. All arches will be open spandril-rib type. The 212 ft. span will be carried on two ribs 12 ft. wide, 24 ft. apart. All other spans will be carried on three ribs, the outer ribs 6 ft. wide and the centre rib 12 ft. wide, with a clear distance between ribs of 12 ft.

SINKING AND CONCRETING A MINE SHAFT

Some interesting and novel details in underground construction were developed in connection with the sinking of a shaft at the Miami Copper Company's Mine, Arizona, U.S.A. The shaft had to be sunk to a depth of 936 ft., and blasting operations became impossible below 200 ft. depth. This work has been fully described in a recent issue of "Engineering News-Record" by Mr. Richard L. Russell, Superintendent of the Foundation Company, Miami, Ariz., and we reproduce the article in question with illustrations by the courtesy of the periodical mentioned above.—ED.

THE shaft described here has four compartments and is 936 ft. deep, and the concrete lining was carried on at the same time as, and without interference with, the sinking, 700 ft. of the shaft lining having been placed and two large stations having been excavated and concreted by the time the shaft had reached its final depth. The section, shown in *Fig.* 1, is 13 ft. by 16 ft. 4 in. clear, and required an excavated section 15 ft. by 19 ft.

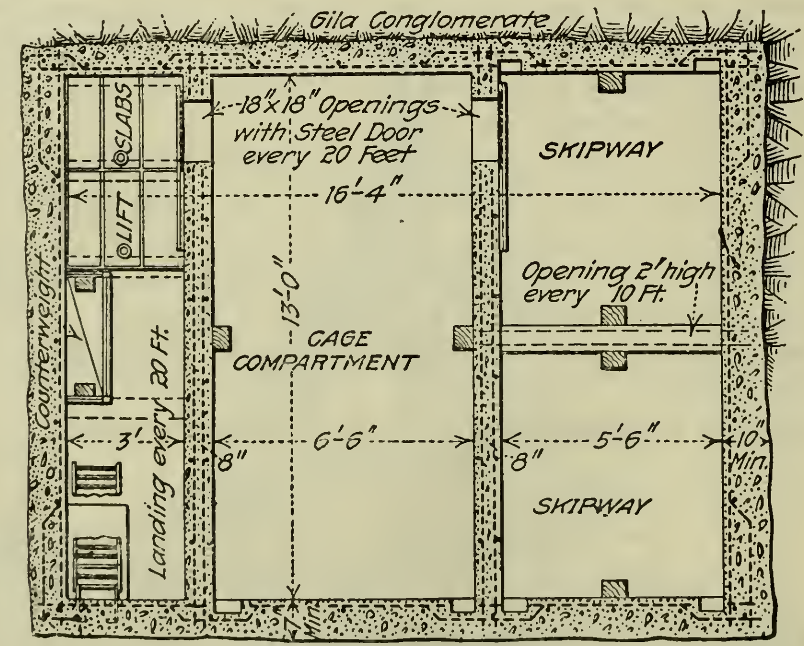


Fig. 1. Cross-section of Shaft, showing concrete lining.

The entire shaft lies in what is locally known as Gila conglomerate, a formation which is typical hardpan rather than a true conglomerate. Although the material is very hard, no blasting was done after water was encountered at a depth of about 200 ft., it being found practically impossible to remove the powder fumes from the fissures in the water-laden hardpan. Light jackhammers with "bull points" from 2 ft. to 3 ft. long were used to break the ground. This method, besides permitting the walls to be trimmed neatly, with far less overbreak than would result from blasting, permitted a progress of 100 ft. per month.

The shaft was located on the side and near the top of a small, steep hill, the top of which was graded down by the contractor to the elevation of the collar of the shaft. The plant lay-out is shown in *Fig.* 2. The shaft being near the present operating plant of the Miami Copper Co., the air, water, and electricity were delivered by that company at the collar of the shaft.

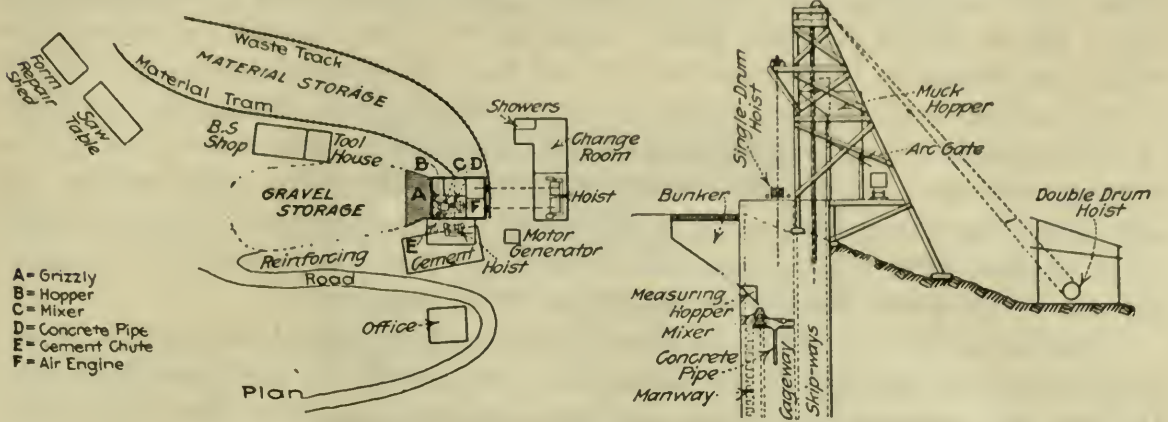


Fig. 2. Plan of Construction-plant Lay-out for sinking and concreting Mine Shaft.

The contractor began erecting the headframe and other working structures on December 11th, 1917, and hand excavated for the top 25 ft. of shaft without blasting, in order to avoid disturbing the ground adjacent to the collar. As the hoist could not be delivered until the end of January, 1918, the contractor obtained, late in December, permission to drift in from a tunnel of the Miami Copper Co. which passed within 20 ft. of the southerly corner of the shaft at a depth of 118 ft. This permitted the tramming of muck by hand a distance of about 300 ft. through the tunnel to a dump in the gulch at the tunnel entrance.

After the line of the shaft was reached, a raise was driven for the purpose of meeting the excavation from the surface. This raise was 2½ ft. by 6 ft., of which 2½ ft. by 2 ft. was a manway with ladders and the remaining space was occupied by a cribbed chute. At the tunnel level the drift was widened and the full shaft section excavated to make a working chamber large enough to accommodate a switch, which permitted the sidetracking of an empty car while another car was being loaded.

The full section of the shaft was then broken down through this chute by the use of 40 per cent. dynamite.

The drift was started on December 26th, 1917, and completed on January 1st, 1918; the raise was started on January 2nd, 1918, and completed at 6 a.m., January 8th, 1919—a rate of 5 ft. per eight-hour shift. The full section of shaft was excavated to the level of the tunnel on February 20th, 1919, and 60 ft. of shaft had been concreted in the same period, as follows:

As soon as the excavation had reached a depth of 35 ft. the forms for the 25 ft. collar were started on 12 in. by 12 in. bearing timbers, placed in 18 in. hitches cut in the hardpan walls. No back forms were used, and the whole 25 ft. was poured continuously. As no water was encountered, no timbering was necessary.

While the collar was being concreted, the excavation had progressed to a depth of 55 ft. Hitches were again cut in the walls, and the three 12 in. by 12 in. bearing timbers were lowered into them. On these bearing timbers was placed a timber frame, the exact size of the concreted section, which served both as a bottom form and a sill on which the form panels could be set. The vertical reinforcing rods were then hooked to the verticals which had been left projecting from the bottom of the previous concrete, and the horizontal reinforcing was wired to the verticals. A 5 ft. section of forms was then placed and concrete was poured, this process continuing until the concrete was carried up to the bottom of the collar section. It was found that the ground would safely permit the opening up of a depth of fully 25 ft. of shaft without lateral support, and the concrete was carried down in 20 ft. sections by the above process for the first 200 ft. of the shaft.

As soon as the raise from the tunnel level was finished and the breaking down process was well under way, a small air hoist was installed at the tunnel level, and the two skip compartments were sunk and timbered as a pilot shaft, this muck being hoisted to the tunnel level and also trammed through the tunnel. Thus excavation was being carried on simultaneously at two levels without interference, while waiting for the double hoist to be delivered.

By the time the whole shaft had been excavated down to the tunnel level a two-compartment pilot shaft 100 ft. deep was ready, one compartment serving as a chute through which to draw off the muck from breaking down the full section of the shaft and the other a hoisting compartment to the tunnel level through which the muck was still trammed.

Water was encountered at this depth (218 ft. below the surface) and while the full shaft section was being excavated to this depth the double-drum hoist was delivered and installed and a special crosshead was devised to comply with the requirements of the Arizona mining laws and at the same time permit the bucket to be dumped into the receiving bin in the headframe without excessively increasing the height of the latter.

As it was neither possible nor desirable to keep the bucket guides extended nearer the bottom than 15 ft. to 30 ft. while sinking was in progress, this crosshead had to be such that it could be stopped at any desired point in the shaft as well as at the headframe and allow the bucket or skip to continue on, for filling or changing at the bottom or dumping when reaching the headframe. This was accomplished by the arrangement shown in *Fig.* 3.

A lug, *D*, was securely clamped to the cable about 6 ft. above the shackle loop. This lug engaged the dogs, *B*, and thus attached the crosshead securely to the cable. When the crosshead reached the top of the headframe, the top lander pulled the lever, *E*, and slid the frame, *A*, over against the guides and gave the lowering signal. The bumper, *C*, then hit the frame, *A*, the dogs, *B*, released the lug, *D*, and the crosshead was left resting on the frame, *A*, while the bucket was dumped, after which the latter was raised high enough to take the crosshead off the frame, *A*. The frame was then slid back and the bucket with the crosshead attached was ready for lowering. At the bottom of the shaft, or at any other point where free use of the bucket was desired, stop blocks, *E*, were bolted to the guides and performed the same function as the frame, *A*, at the headframe. This crosshead gave perfect satisfaction.

From the 218 ft. depth to the bottom the full section of shaft was excavated by the use of bull points; three men using jackhammers working them into the material loosened all that four muckers could load into the buckets.

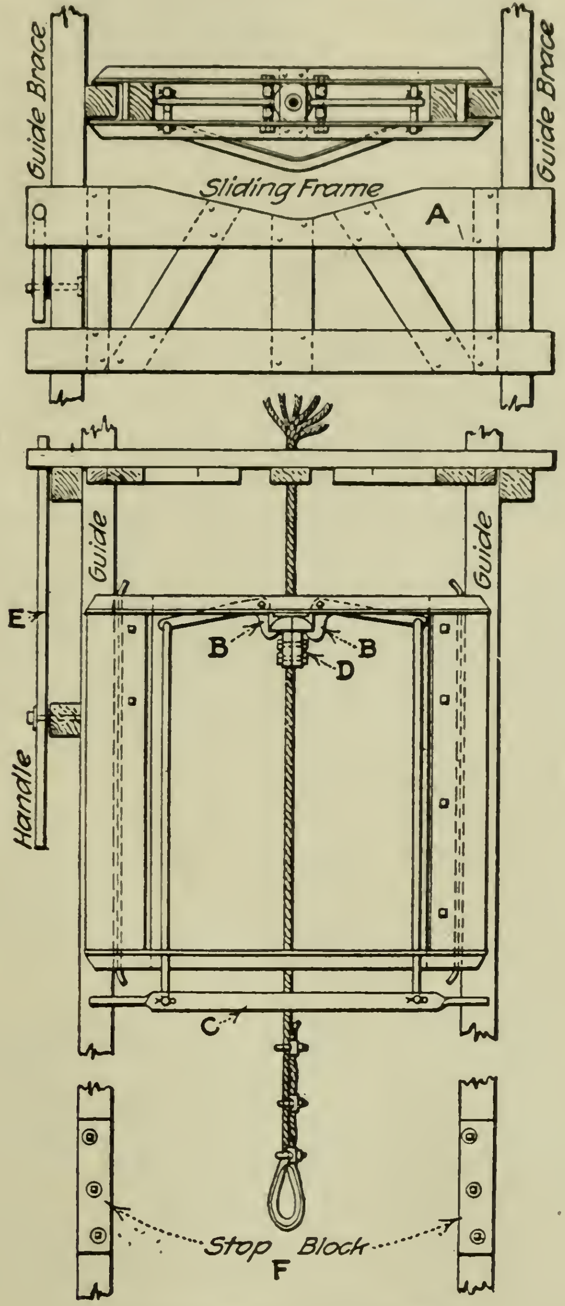


Fig. 3. Cross-head and safety devices.

It was found that the water caused the hardpan to slough very treacherously soon after a wall was exposed. Full timbering was, therefore, carried on with the excavation from the 250 ft. depth; 8 in. by 8 in. plates, posts, and dividers and 2 in. lagging were used. Corner joints were framed as shown in *Fig.* 4, in order

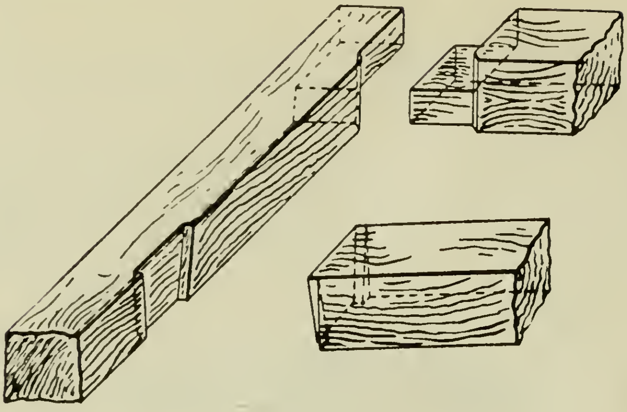


Fig. 4. Detail of timber framing.

to secure an increased bearing surface. As the shaft was concreted, all timber and lagging were removed and re-used, some timbers being used as many as four times. This not only resulted in a large material saving but also saved a high framing expense, as carpenters were paid $7.25 per shift at that time.

The section concreted in one operation was increased to 100 ft.; that is, the 12 in. by 12 in. bearing timbers were lowered 100 ft. and set in hitches and the 100 ft. section was concreted upward in 5 ft. courses.

The water was baled into buckets and hoisted, five buckets per hour, or 600 gal. which, together with the water shovelled and hoisted with the muck was sufficient to keep the bottom free. A timber bulkhead 6 in. thick was kept not over 50 ft. above the men working in the bottom over all of the shaft except the two skip compartments. While the reinforcing and forms were being set in one of the skip compartments all the hoisting from the bottom was done in the other compartments, and after the forms were set one of the skip compartments was bulkheaded at the level of the top of the forms, as were the cage and manway compartments, one skipway only being left open for hoisting.

Upon the completion by the contractor of the contract for lining with concrete the old shaft No. 3 of the Miami Copper Co., a mile distant from the new shaft No. 5, about April 1st, 1918, the single-drum hoist from shaft No. 3 was installed at shaft No. 5, as shown in *Fig.* 2, working from extension timbers from the same headframe and operating in the cage compartment.

This hoist handled all reinforcing, forms, concrete pipes and timbers to the form and concrete gangs, and as there was always a bulkhead in this compartment over the men in the bottom, the danger of working at two different levels was greatly lessened. This hoist was also used in pulling and resetting the rather heavy wooden forms in all compartments. It proved nearly as fast as a derrick and obviated the use of the slow and expensive block-and-tackle method.

Separate bunkers for sand and gravel were excavated immediately adjacent to the collar of the shaft at the manway end, and the sand and rock from the crushing plant, which was installed in the creek bed, was dumped through grizzlies into these hoppers. Through openings left in the shaft collar, with arc gates, the sand and stone passed into measuring hoppers inside the manway and cage compartments. These hoppers were of the proper dimension for a one-bag batch, and from these hoppers the material was chuted to a batch mixer located in the shaft cageway compartment 20 ft. below the surface. The cement was slid in bags down a chute from the door of the cement shed through an opening in the south side of the cageway compartment directly to the mixing plant.

The mixer, of 8 cu. ft. capacity, was belt-driven from a small air hoist set at the same level. This plant occupied the southerly half of the cage compartment and manway compartment, the wall between the two being omitted temporarily for its accommodation, the whole plant occupying an area only 7 ft. by 9½ ft., as clearance for buckets and material handled by the small hoist in the cage compartment had to be maintained at all times.

The 1 : 2 : 4 mixture of concrete was dumped from the mixer through a 6 in. iron pipe with screwed couplings and with the fall broken at junction boxes every 300 ft. and at the swivelled chute which carried the concrete to the forms around the shaft. This pipe was supported by timber clamps resting on 6 in. by 8 in. timbers carried in recesses left in the concrete when poured, and on the shaft timbers where the concrete had not yet been placed.

In the manway compartment the permanent iron ladders were placed in position as the concrete lining was placed. In advance of that, the permanent ladders were placed on temporary wooden landings. Concrete-lined stations were located at 235 ft., 490 ft., 576 ft., 643 ft., 729 ft., 770 ft., 835 ft. and 920 ft. below the surface. The 490 ft. and 576 ft., also the 770 ft. and 835 ft. sections were the top and bottom of future ore pockets. The ore pocket between the 643 ft. and 739 ft. stations is now being constructed.

To facilitate the construction of these pockets, 4 ft. by 4 ft. cribbed chutes were excavated before the shaft was concreted just outside of the concrete walls of the north-western skipway, with a gate and a chute leading into the skipway at the bottom of each pocketway. When the ore pockets are constructed the muck will be shovelled into these chutes and drawn off at the bottom and the cribbing removed as the excavation proceeds, thus effecting a considerable economy in the cost of excavation.

For the hoisting in the cageway compartment, cable guides were installed, carried on reels on the headframe and unreeled as the shaft was deepened, and even at the full depth of 936 ft. these did not oscillate enough to cause any difficulty.

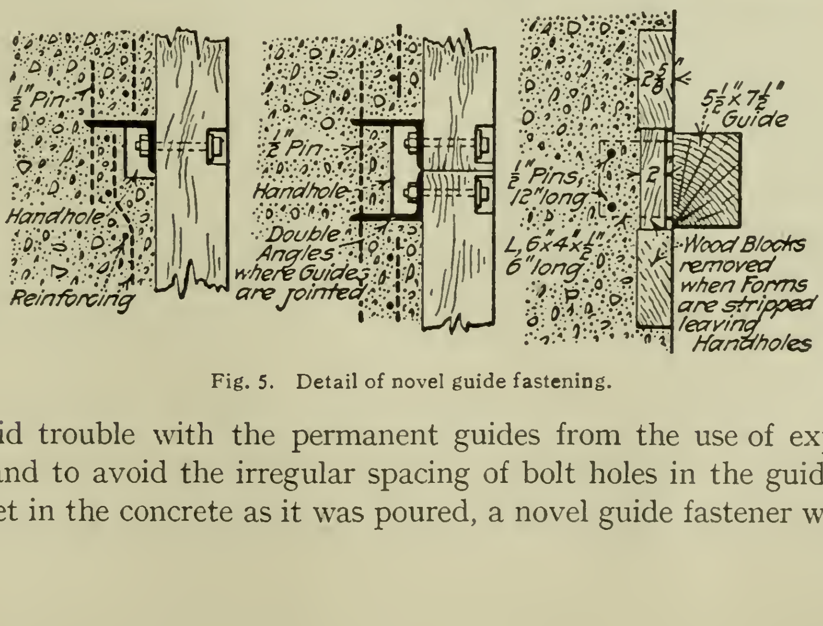

½" Pin
Handhole
Reinforcing
½" Pin
Handhole
Double Angles where Guides are jointed
2⅝"
5½"x7½" Guide
½" Pins, 12" long
2
L, 6x4x½", 6" long
Wood Blocks removed when Forms are stripped leaving Handholes

Fig. 5. Detail of novel guide fastening.

To avoid trouble with the permanent guides from the use of expansion bolt fastenings, and to avoid the irregular spacing of bolt holes in the guides if anchor bolts were set in the concrete as it was poured, a novel guide fastener was designed.

It was built in the concrete as poured, but still allowed drilling of the bolt holes by templet after the shaft was completed and allowed a leeway for any reasonable irregularity in location while pouring. These fasteners are shown in *Fig.* 5.

A chart was kept showing the progress made each day by each shift on each part of the work. A large-scale elevation of the whole shaft, stations, tunnels and ore pockets was made, and a certain portion was allotted to excavation, timbering, form work, reinforcing, concreting, etc. To each shift boss was assigned a certain colour, and the portion of the chart representing the location and the amount of work done was coloured for the shift doing the work. The date was then written through the colour. Quantities for this purpose were determined both by actual measurement and by the foremen's reports. For instance, the number of buckets of muck hoisted was at close check on the advance in sinking for that shift. The foremen were never formally notified that this chart was being kept, but within two days from the time it was instituted they all seemed familiar with it and watched it closely.

This chart not only furnished information as to progress at all times and gave a comparison of the work accomplished by each shift, but it also served as a record which showed at a glance which shift boss had excavated any part of the work. If faulty workmanship had been discovered it would have been simple to trace it.

Probably the greatest value of the chart, however, lay in the competition it aroused among the shift bosses, who realized that their work was being closely followed and that they were getting due credit.

In spite of the fact that the hardpan through which the shaft was driven is so firm that all former shaft sinking in the district had been done by blasting, it sloughed badly upon exposure to the air, and this without warning. Ground which had been sounded and found solid but a few minutes before would suddenly fall with no warning, so that the sinking combined the difficulties of both hard-rock work and soft, treacherous ground. In spite of this fact, there have been no serious accidents to either construction or the employees during the entire work, which means that while every precaution has been taken to safeguard the men and the work, good fortune has also favoured the job.

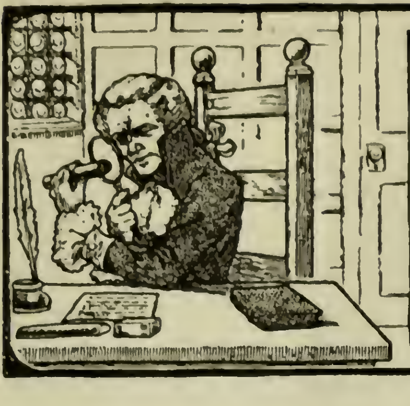
MEMORANDUM.

Large Concrete Building at Stockyards.—Fire-resisting and sanitary conditions at a large double-deck sheep barn for the Denver Union Stockyard Co. are insured by the use of concrete. The structure is 422 ft. by 320 ft., having storeys 12½ ft. high, with no side walls, although a 4-ft. parapet extends around the second floor. The panel spacing is 16 ft. by 16 ft., except for a 20-ft. width at the central driveway. Inserts in the columns provide for the attachment of fences and gates to form pens. Concrete drinking troughs are provided.

Flat-slab construction for the second floor is designed for a load of 150 lb. per sq. ft. Drainage planes formed in both floors provide for flushing. A sawtooth roof is used, but with a flat slab for the four outer panels, where it is assumed that sufficient light will be afforded by the open sides. Concrete ramps about 15 ft. wide have grades of 16 per cent. for the sheep runs and 11 per cent. for driveways used in handling supplies.

To resist wear from hoofs a 1-in. granolithic finish is given to the floors and ramps.

While the first cost was approximately double that of a timber structure, the repair cost is reduced to a minimum, and the fire-resisting and sanitary qualities are special advantages. This building was designed and built by the C. S. Lambie Co., Denver, Colo., its details and reinforcement being planned by the Corrugated Bar Co., Chicago.



REINFORCED CONCRETE ACCIDENTS IN GERMANY FROM 1911 TO 1918.

(Continued from August Issue).

By Dr. W. PETRY, Obercassel.

The following is a translation from the first part of an article which appeared in Beton u. Eisen from the pen of Dr. W. Petry of Obercassel. In reproducing this account of accidents to structures of reinforced concrete we think a useful cause will be served as the investigations here dealt with plainly show that it is not the material which is at fault, but rather that the failures are due to other causes, as a perusal of the subjoined article shows. As stated below, the accounts of such accidents to reinforced concrete structures are frequently exaggerated or inaccurate, and it is not legitimate to infer the untrustworthiness of this form of construction from the occurrence of accidents. But on the acceptance of the fact that it is by our failures we learn rather than by our successes, we publish this report, hoping it may be of use and interest to our many readers.—ED.

CASE 13.—*Collapse of a Reservoir.*—Defective statical computation and defective execution. A pure water reservoir was enlarged by the addition of a new reinforced concrete portion. Eight weeks after the concreting was finished, and the cover of earth, 1 metre thick, was put on, about one-third of the roof collapsed, also destroying the outer longitudinal wall. No cracks or sinking of the roof had been seen on removing the centreing, and the portion which remained standing withstood the official tests successfully. The only eye-witness, a workman, said that the outer wall buckled before the collapse ; he did not know if cracks appeared in the roof. Some months after it was found that the statical computation, although generally correct, was defective in some respects. The reinforcing rods in the ribs of the plate beams were not correctly allowed for, and only the moments, but not the concrete stresses in the continuous beams over the supports, had been computed. Subsequent calculation gave here 60·6 kg./cm.^{2}, whilst 30 kg./cm.^{2} had been assumed as permissible. The expert also found that the concrete mixture was only 1 : 6, and the gravel was too small. The Material Testing Station found in four specimens of the concrete the ratios 1 : 6·7 to 1 : 7·4. In spite of the age of the concrete, the compressive strength was only 49 to 72 kg./cm.^{2}. The mixture for the columns was not given in the statical computation, and no cubes for tests were made during the work. The adhesion also seems to have been imperfect ; at least photographs show that the concrete separated cleanly from the iron. The design in itself was unobjectionable, and the centreing, etc., was satisfactory. Whether the reinforcement was correctly placed could not be determined.

CASE 14.—*Collapse of a Reinforced Concrete Saddle Roof.*—Incorrect statical computation and bad execution. This building was undertaken by one contractor, who handed on the reinforced concrete work to another firm. The latter had computed the principals as horizontal, freely supported beams on two supports, neglecting the horizontal thrust which must occur owing to the bent form ; the crown was also not properly formed to resist bending. The centreing of these principals was removed after 17 days instead of 30 days as officially prescribed. The concrete was found to be still moist, imperfectly hardened, and full of cavities.

CASE 15.—*Breaking of a Reinforced Concrete Floor.*—Causes: imperfect statical computation, loading unprovided for in the computation, bad execution. This floor was computed for the smallest working load allowed by the building regulations—namely, 125 kg./m.^{2}, which is extraordinarily low for a factory room of 4 metres in height. Later a small tramway was added, which had not been allowed for. The floor was overloaded, and it and the neighbouring beam threatened to break down, although this was prevented by supports in time. The expert found that neighbouring parts of the floor were carrying 675 and 1,180 kg./m.^{2}, and determined that the injured part was loaded with 1,080 kg./m.^{2}, or about eight times the load provided for. Fracture took place when the stress in the steel was 3,170 kg./cm.^{2}. The statical computation was bad, all sections of the floor being assumed to be equally loaded, instead of allowing for a movable load; this makes the moments 28 per cent. too low. The span was taken as 3·8 metres, whilst it was actually 4 at the place of fracture. Shearing stresses were not calculated, and working drawings were not provided, so that the intended positions of the reinforcement could not be determined. Where iron was exposed by chipping it was found to be defective. For instance, the reinforcement had been computed as continuous, but there were no upper rods above the supports. The lower rods in some cases extended insufficiently far over the supports, in others they stopped short of them. The ends were hooked, but the hooks lay flat. In one of the beams the rods were placed quite at random. Moreover, the reinforcing rods were only 26 mm. in diameter, the computation having assumed 30 mm.

CASE 16.—*Collapse of a Floor.*—Cause: bad execution. The gravel was obtained free from a neighbouring pit, and was clayey and full of plant roots; the cement was very slow setting. The directing architect stated that he had notified the builders of this fact, but that it had not been remedied. The investigation, made immediately after the failure, showed that the reinforced concrete beams were only 46 cm. deep instead of the prescribed 50 cm. The reinforcing rods were laid irregularly; some were too high and were not provided with hooks, so that they pulled completely out of the supports. The stirrups did not extend far enough into the plate, so that the plate separated completely from the beam. The concrete cracked away from the steel, and contained nests of stones and of unmixed cement, besides clayey and sandy portions and masses of straw and rushes. It was said that the women who mixed the concrete used a sack of powdery slaked lime in place of cement.

CASE 17.—*Collapse of a Parapet Wall.*—Cause: defective execution. The path beside the roadway of a bridge over a stream consisted of a partly overhanging concrete plate 22 cm. thick, carrying at the outer edge a parapet wall 1 metre high and 20 cm. thick. This was united to the plate by the reinforcement, the rods of which were irregularly spaced. The abutment was concreted first, and the plate and parapet were only added several weeks later, gravel concrete 1 : 3 : 4 being used. The centreing was removed after three weeks, when the plate and parapet broke away from the structure and fell down. The expert could not examine the junction between plate and support, because a new plate was put in place immediately after the accident. The concrete which remained was extraordinarily variable in texture in different layers, and had many cavities in places. The fragments were quite smooth on the under side, so that there can have been no real union between them and the supports. Evidently the latter were not roughened or coated with thin cement paste before beginning the work. The expert concluded that the union at the joint was very imperfect, although the computation showed that the tensile stress at the joint would be small, but that the plate and supports should have been anchored together. A second expert believed that the cement was probably defective, which might happen in war time.

CASE 18.—*Collapse of a Cellar Roof.*—Causes: defective construction, bad execution, insufficient supervision. The expert found that the bent reinforcing rods (the roof was vault-shaped) were sufficient in number and dimensions, but the upper reinforcement was absent from both abutments. The concrete was irregular, dense at the right abutment, very porous at the place of fracture. At the time of the accident it was insufficiently hardened, although five weeks old. According to the expert, in such wet weather the centreing should not have been removed for another two weeks, or at least some supports should have been left. The person responsible had had no sufficient previous experience of reinforced concrete work.

CASE 19.—*Failure of a Reinforced Concrete Hall.*—Causes: defective construction and execution, departure from the statical computation. This was a factory building with arched roof, constructed as a doubly hinged arch with steel tension member. The roof collapsed on removing the centreing. The concrete was unexceptionable and the steel good. The reinforcement in the arches was not always correctly placed, being 9 or 10 cm. from the inner edge instead of 3 cm. as provided for in the computation. The junctions of different rods were incorrectly arranged, and it was at these points that fracture occurred. The actual cause of failure was the incorrect construction of the tension members, and the court found that bad anchoring caused the accident.

CASE 20.—*Failure of a Cellar Roof.*—Causes: departure from the statical computation in execution, defective execution, insufficient supervision. As good soil was only found at a depth of 5 or 6 metres under a 3 to 4 metre layer of peat, it was decided to erect reinforced concrete pillars at the crossings of the walls of a two-storied dwelling house. These pillars, 40 by 40 cm., transmitted the load by means of plates, 140 by 140 cm., to the firm ground below. The total height of the pillars was 4·90 metres, they projected 2 metres above the cellar floor and carried the reinforced concrete of the cellar. Part of the building collapsed on removing the centreing from this roof. It was found that one pillar had completely sunk into the ground and that another had split along its whole length. Both were exposed for their whole length by digging. The first one proved to be only 30 cm. square and had completely buckled. The other had been originally 30 by 32 cm., but as one joist which it should have carried was not in the right place, but 20 cm. to one side, an addition had been made to the pillar, 20 cm. thick, without any union with the rest of the pillar. This added portion had split away. The remaining joists had broken and brought about the collapse of part of the building. The plates were not in sound ground, which was only found 1 and 1·4 metres respectively beneath them. The concrete was a 1 : 4 mixture, and tests of the same mixture gave 133 kg./cm.^{2} after 28 days. The concrete of the foundation plates was badly mixed and friable, being very inferior at the base of one of the columns, the peaty water having apparently hindered setting. One column showed defective places filled with peat. The business manager of the contractor and his technical assistant, who entrusted the supervision to a mason with no previous experience of reinforced concrete, had charge of the work, contrary to regulations.

Case 21.—*Collapse of a Reinforced Concrete Vaulted Roof.*—Causes: incorrect statical computation, departure from the computation in execution, defective execution, loading beyond that provided for. This was a vaulted reinforced concrete roof of 12·5 metres span. Above it was a steel roof skeleton, in the middle of which was a gangway, unconnected with the vault. The construction of the roof was given to the lowest tenderer, contractor A. The roof was required to carry a load of 80 kg./m.^{2} in addition to its own weight; of this 50 kg./m.^{2} would be transmitted to the three steel roof principals by ties, whilst the columns, without tension rods, were to take the thrust of the vault. The contractor undertook the full responsibility for the work, and pledged himself to follow the official regulations. He entrusted the calculations to B., who was not competent for this rather difficult undertaking. B. treated the vault as a suspended Rabitz roof, which does not usually require an official permit, and gave the necessary thickness as 5 cm. The arched steel rods lay about the middle of this 5 cm. layer, and therefore could not exert much effect. Good concrete was put in place by the concreter C. The thickness proposed was not always attained; some places 2·5 cm. thick were found, and there were holes right through the mass. The centreing was removed a month after the completion of the structure, and 14 days later suspended from the steel. The suspension was defective. A month after this the roof was plastered and smoothed on the inside, when no cracks were noticed. Seven months after the removal of centreing heating apparatus was placed in the roof space, carried by the steel and unconnected with the vault. Workmen walked over the concrete during this work, and found that it trembled violently. The heating caused a strong draught through the ventilation openings in the roof. The architect D, appointed by the city, requested the municipal machine department to close the openings with iron valves. This was done without notifying the building authority. Porous stone rings, 15 cm. high, were cemented round the openings, and these were capped by frames weighing 360 kg. each, making 280 kg./m^2., in addition to the temporary load of three workmen, making 200 kg., whilst the roof should only have carried 80. The men noticed cracks and holes in the roof. Fifteen months after the beginning of the roof the cracks were so conspicuous that they could be seen from below. The contractor then, with the concreter C, went into the roof space to see how the cracks could be stopped. As they stepped on to the roof it began to collapse. Six reports have been submitted by experts. One of them gives as the immediate cause of the accident the following: The air exhaust appliance was only loosely connected with the vault, and a long crack ran below it, so that several hinges were formed, and the hinged portions were in unstable equilibrium. The one-sided loading caused by two persons stepping on to the structure led to the collapse. The charge before the tribunal was that A should not have left this structure, acknowledged to be a difficult one, entirely to B; he should have submitted a special design to the building authority, and should have exercised better supervision over the work. B was chiefly responsible, since he gave specific dimensions for the construction and thereby led A to believe that he was competent to compute such a roof; he should have seen that his design was first submitted to the authority. C should have made sure that the thickness prescribed to him was actually observed. The municipal building officials D and E were to blame, since they omitted to insist on a special design. They believed that the structure was a suspended Rabitz roof, permission for which had been previously given by the authority, whilst the actual structure was a partly cantilevered roof; this should have been notified. They should also have given more attention to the gradually spreading cracks. The building official F also believed that the structure was of a type which did not call for a special permit, but he should have noticed that the suspension did not correspond with that on the drawing which he had already passed. A and E were prosecuted and acquitted, the tribunal deciding that in spite of all defects the roof was in itself stable, and that the collapse was due to the addition of the ventilation appliances, which were too heavy for the roof. That this happened was due to the lack of co-ordination between the machine and building authorities. There were no regulations on this point, so that the blame was not to be attributed to the accused, but to the lack of organisation of the municipal departments.

CASE 22.—*Collapse of a Front Wall.*—Causes: Inexact statical computation, departures from the building plan, bad execution, insufficient supervision. A dwelling house was being reconstructed when a large part of the front wall collapsed owing to the giving way of a reinforced concrete beam and the reinforced concrete column beneath it. Immediately after the accident the inspectors found that notable departures from the authorised plan had occurred, and that the concrete in the beams was inferior and that in the columns porous and loose. Tests gave 1 : 4·9 in the beam and 1 : 9·4 in the columns, the respective strengths being 73 and 46 kg/cm². The concrete was set in place in very hot weather, and several wooden wedges were knocked out from under the beam shortly after concreting. Four months after the accident an expert showed that the computation used as the basis of the official authorisation was in some respects irregular, but that the failure would not have occurred if it had been properly followed. The contractor had altered the design on his own account and made a new computation. The beam was assumed in the first computation to carry a load of 51 tons, in the second only 34 tons. The column was originally intended to be of iron, but was erected as a reinforced concrete column 22 by 30 cm. An exact calculation showed that it bore a load of 69 tons, whilst the erroneous computation only assumed 31 tons. The concrete in the column was actually subjected to a load of 70 kg/cm². A second expert pointed out that the contractors were to blame for having entrusted the supervision to a 26-year old engineer, who was so pressed with work as to be unable to give proper time to it. The contractors themselves admitted before the tribunal that they did not understand anything whatever of reinforced concrete.

Conclusions

1. Of the 22 cases investigated only 13 were actual reinforced concrete structures; 4 were not of ordinary reinforced concrete types; in 5 the cause did not lie in the reinforced concrete construction, but in some external factor, such as supporting masonry or wooden centreing.

2. In the 13 reinforced concrete cases, the cause of failure was not single, indicating a weakness of this method of construction, but consisted always in a combination of circumstances, faults and infringements of well-known rules of building, especially in regard to this material.

3. In these 13 cases these errors may be traced to the fault of the contractors or their agents, although the building authorities are not always free from blame.

4. The same may be said of 6 of the 9 cases mentioned above of structures which are not true reinforced concrete.

5. As far as these investigations go, the accidents to reinforced concrete structures are not to be attributed to this mode of construction, but have occurred through being undertaken by contractors or their subordinates who lacked the necessary training and experience. The worst of it is that anyone may build in reinforced concrete, whether he understands it or not, and this can only lead to bad work. A further cause of insufficient care is the lowering of prices by unhealthy competition. This leads to underbidding of prices, to a reduction of dimensions to a minimum, and to bad execution. When the prices at which reinforced concrete work was executed in the last years of peace are examined, it is not to be wondered at that even the designs left much to be desired, and that the execution was not as careful as it should have been. Further, such contracts are often undertaken, and any kind of conditions accepted, merely to secure the work, and in order to fulfil these conditions and avoid heavy penalties for delay reckless execution is sure to occur.

In this matter the proprietors and the authorities share the responsibility with the contractors, since they do not exercise sufficient care in the selection of a contractor and give the work out at prices at which proper execution is impossible from the beginning. If accidents are to be avoided or reduced in number, the proprietor must examine closely both the tender and the ability of the tenderer. It must be recognised that good work can only be done when the price is more or less accordant. What is said in one report on an accident is true, that the best regulations for reinforced concrete are of little value when they are not observed. The following extract from the notes to the official regulations for buildings in reinforced concrete, dated January 13th, 1916, is of value:—

"The supervision and construction of reinforced concrete construction demands a thorough knowledge of this method. The proprietor must therefore only entrust the work to such contractors as can guarantee such knowledge and careful execution. Proof of this must be furnished. Further, the contractor should only appoint such persons as the responsible supervisors of reinforced concrete construction as are thoroughly acquainted with the method ; the actual work should be supervised by such master-masons or trustworthy foremen as have already undertaken such work successfully."

When we examine how far this condition was fulfilled in the cases described above it is easy to see where the root evil of the accident question lies. The accident statistics of the German Commission for Reinforced Concrete confirm the statements of Prof. Siegmund Müller in 1912 :—" The total result of these records shows that even with such a satisfactory method of construction as reinforced concrete, causes of accident may present themselves in the most various parts of the statical computation, the structural designing, and still more in the execution, when incompetent firms undertake large building operations."

The warning of the official regulations should therefore be taken to heart, namely, that proof should be demanded that the contractor possesses a thorough knowledge of the method, and can guarantee careful execution.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

AMERICAN CONCRETE INSTITUTE.

FIRE HAZARDS MET IN STORAGE OF FUEL OIL.

By J. W. LORD, Engineer, Boston Manufacturers' Mutual Fire Insurance Company, Boston, Mass.

Among the papers read at the recent Convention of the American Concrete Institute was one relating to tanks for the storage of fuel oil, a form of construction which was extensively used during the war on account of the shortage of hard fuel, and of the steel of which to make tanks. An abstract of this paper is given below.

PETROLEUM as fuel for mechanical purposes was first used at the refineries of the oil companies, where by-products were used under boilers and for heating. The first application in furnaces at factories insured by the Associated Factory Mutual Fire Insurance Companies was about 1888. The introduction, however, was gradual. As early as 1889, following the well-known policy of the company of advising its members as to safeguards needed for adequately protecting their interests, preliminary rules for installing fuel oil were drawn up by the Boston Manufacturers' Mutual Fire Insurance Co., and in this, as in all similar work, the idea was not to raise arbitrary objections to processes which were deemed advantageous, simply because involving a hazard, but rather to advise what experience showed to be necessary in order to remove the hazard or take precautions so that it would not endanger the establishment itself or the continuity of its operation.

As an outcome of investigations and experience, it was definitely determined that either a gravity feed for burners, or delivering oil under air pressure, which is in a way equivalent to a gravity system, was not safe, and ought not to be used at any plant. Direct pumping to burners is the only safe practice, and this has been adopted as a standard. At first, in some cases, the standpipe for maintaining a constant head was adopted, but this practice was discontinued, pressure now being maintained by pumping against a relief valve with an overflow back to the tank. By this means a very uniform pressure is available.

All fuel-oil storage should be underground. The tanks should be located well away from main buildings, and not near fire protection mains. Each tank should be independently vented, and the vents should be protected by fire arresters. Steel tanks should hold not more than a carload, and should be rustproofed, and, if set in a pit, should be filled around with sand or sound earth free from acid or ashes.

RULES FOR CONSTRUCTION OF CONCRETE TANKS.

Quite recently, concrete has been successfully adopted for fuel-oil tanks of large capacity, and rules for the construction of these have been formulated by the inspection department of the Associated Factory Mutual Fire Insurance Companies. Whether steel or concrete tanks are used, all connections should be taken from the top, as otherwise in the event of settlement the piping will become broken and the entire contents of the tank discharged, incurring not only loss of the oil, but possibility of danger. Great difficulty has also been experienced with concrete tanks in making connections oil-tight when under pressure.

The unloading station for tanks at the railway siding should be located well away from buildings, should be level to avoid possibility of a tank-car moving after unloading has commenced, and the ground should be sloped so that oil could not reach buildings in event of accident while unloading. The unloading station should have a metal or concrete pan so that oil will not saturate the ground ; this should be large enough to catch the entire contents of the car. The connection for the tank car should be of either pipe with swing joints or metallic hose, thus avoiding rubber hose.

Where storage tanks are installed in batteries there should be valves in connecting pipes between tanks, so that any one tank may be cut out at will. All connections into tanks should extend to the bottom, so that the end of the pipes will be sealed.

There may be cases where it will be found impracticable to bury the storage tanks, and in a large yard, where the ground slopes away from the buildings, they may be sometimes safely arranged by building the tank above ground and surrounding it with a levee, enclosing a space sufficiently large to contain one and one-half times the entire contents of the tank, with an allowance for an accumulation of snow and water. The levee should be drained, and discharge pipes should pass over the levee rather than through it. A tank should never be installed under these conditions near enough to buildings to cause damage if on fire.

Whatever the location of the tank, delivery should never be by gravity. In some cases a small service tank, which should be lower than the pump, may be used, and this may be filled from the storage tank by means of an open connection using a funnel. The service tank is not advised, however, unless necessary, as it complicates the system and introduces the spilling of oil at funnel connections.

The pump maintaining pressure to burners should always be located at higher elevation than the tank, and should be so arranged as to prevent siphonic action when the tank is higher than the burners.

All piping should drain back to the storage tank from the burners. The suction pipe should have a foot valve, in order to avoid delay in starting, and also to keep the pipe full, and should be so arranged that the foot valve may be readily removed. Piping should be buried and exposed only where rising from the ground to the burners. It should never be overhead. Valves should all be of the outside screw-and-yoke type, so that their position may be seen at a glance.

Fittings should be extra heavy, and the entire oil system subjected to 150 lb. hydrostatic pressure before being used, as when a burner or pipe becomes clogged there is a tendency to clear by rapping on it, and if the pipe is weak it will be broken and discharge the contents on the floor or into the furnaces.

The supply of oil and air or steam for atomising should be interlocked in such fashion that if for any reason the air or steam for atomising should fail the flow of oil would also cease. This can be accomplished, where air is used, by driving a rotary pump by a sprocket chain from the blower supplying the air for atomising. A reciprocating air pump should have the air supply taken from the same line as the atomising supply and beyond the point from which the air for atomising is taken. Where a steam pump is used and air for atomising, the steam for the pump should be controlled by a valve actuated by the atomising air pressure. With a reciprocating steam pump and steam used for atomising, the steam for both purposes should come from the same source.

PUMP AND PUMP HOUSE.

The pump house should be made non-combustible, with brick or concrete walls and concrete roof. If located inside the main building, the pump should be cut off from the remainder of the room by a substantial masonry wall. If electrically driven, the motor should be cut off from the pump room by a non-combustible partition, and pumps operated by shaft passing through the wall, with switches and fuses located in the motor room.

There should always be a by-pass around the fuel oil pump so that all oil may be drained for repairs.

Furnace buildings should, as far as possible, be non-combustible throughout and with all steelwork protected by concrete, and should ordinarily be protected with automatic sprinklers. Where fuel-oil apparatus is located in upper stories of buildings, oil pipe should run up the outside of the building and be protected by encasing in a larger pipe, the furnace being located close to the outside wall so that the run of piping inside may be kept at a minimum. The inside piping should be laid in covered shallow trenches in the floor. Where an oil pipe necessarily runs under a building, it should be encased in a larger pipe made up with tight joints pitched to drain outside the building to small wells, so that leaks may be quickly detected.

Where a tank is filled by tank wagon the inloading station should be at the kerb, so that the tank wagon need not enter the yard where fire in the tank wagon might cause large loss to buildings in the vicinity and it would be extremely difficult to extinguish it.

Although a considerable amount of fuel oil now being used is of heavy grade, it should be understood that under certain conditions the oil presents all the hazards of a lighter oil. In order to use the heavier grades at all, it is necessary to heat them, which results in fluidity and introduction of the hazards of the lighter oils. The apparatus as installed will be permanent, and it is entirely possible that with the discovery of new oil fields lighter grades may be used. There have also been cases where unsuitable oil has been received and attempts have been made to remedy the situation by the addition of benzine. The quantity of benzine added would necessarily be indefinite, and the hazard of the oil thus materially increased. It is, therefore, important that with any oil system installed safeguards should be adopted to care for definite hazards.

On the principle that " an ounce of prevention is worth a pound of cure," the efforts of the Boston Manufacturers' Mutual Fire Insurance Co. have been directed largely toward prevention rather than toward method of extinguishing oil fires, although these also have been thoroughly investigated. None of the means of extinguishing ordinary fires is entirely satisfactory when applied to oil fires, and, in fact, there does not at the present time appear to be any certain method. The most satisfactory apparatus, however, is the foam extinguisher, in which two solutions are mixed and pumped on to the surface of the oil, producing a smothering effect and, in cases, complete extinguishment.

GREAT CARE NEEDED IN CLEANING TANKS.

An important feature of fuel-oil storage is the necessity of taking precautions to avoid loss of life when cleaning out the tanks. The vapours are extremely poisonous, and as they are heavier than air it is only possible to remove them from the tanks by pumping out. With the presence of sludge, however, which continuously gives off the gas, this method will not suffice. The only safe way then is for workmen to wear either a diver's helmet or a gas mask, and this precaution should always be taken.

Where the steam in a plant is entirely maintained by the use of fuel oil, any material interruption to this service would result in shutting down the steam plant, and consequently the heating facilities would be suspended. In order to be assured of reliability in oil supply, the pump set should be in duplicate.

Summing up the whole question of the use of fuel oil, the general rules which should be followed are few and simple, and are briefly stated in the following :—

1. Storage tanks should be underground and well away from main buildings and fire mains, and so located that oil cannot flow from them on to the surface of streams in the vicinity.
2. Unloading stations for either tank cars or tank wagons should be safely located and constructed.
3. All piping should be buried and graded to drain back to the tank.
4. Supply to burners should be by pumping, and oil and air or steam for atomising should be interlocked.
5. The entire system should be mechanically strong to prevent the possibility of breakage.
6. Scrupulous care should be observed in maintaining neat and orderly conditions around the tanks, pumps and oil-burning apparatus.

"CONCRETE SHIPBUILDING"

It is our intention to discontinue this series as a special supplement, and to incorporate it in each issue of the magazine.—ED.

REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

CHAPTER VII.

SPEED OF CONSTRUCTION AND WORKMANSHIP.

EXTRAVAGANT claims have been made respecting the speed at which reinforced concrete vessels can be built. A careful investigation of all the existing vessels for which data are available leads to the following conclusions :—

A rowing-boat or small pleasure boat can be completed (as far as the hull is concerned) in about seven days' working time by two men. The boat shown in *Fig.* 40 (December, 1918, supplement) was completed by Mr. Bowman and a labourer in a week.

The boat shown in *Fig.* 39 was completed in 60 hours' working time. (See same supplement).

The first of a series of *larger hulls for barges, etc.*, requires about the same time as a steel hull of the same cubic capacity, but the succeeding ones will require a much shorter time, owing to the bulk of the shuttering or framework being used repeatedly. The second and subsequent hulls of such a series of vessels of 600 to 1,000 tons capacity should be completed under ordinary conditions at the rate of one every four months.

In the construction of a large number of 250 horse-power tugs, built in France, two weeks are sufficient to erect the moulds for the second and subsequent hulls (the erection of the first mould took somewhat longer) and to place the steel in position. The process of concreting requires 48–72 hours. The hulls enter the water broadside on, and an average of three weeks is allowed for maturing. Barges of 1,000 tons deadweight capacity may easily be turned out and launched at the rate of one every ten weeks from each slip in a well-organised yard.

The largest concrete vessel yet built is the *Faith* (see p. 587 of this issue for some recent information regarding this vessel), which was built at an extraordinarily rapid rate, the installation of the engines, housing machinery, and complete equipment being finished in 42 days, and from start to finish only six weeks was required for the whole vessel.

Another example of rapid shipbuilding was that of a vessel built by the Atlas Construction Co., of Montreal. This single-screw steamer is 125 ft. by 22 ft. by 13 ft., and capable of a speed of about 8 miles per hour.

Pontoons may be built at a corresponding rate. A pontoon on the Manchester Canal was commenced in the early autumn of 1911, concreting was started in November of that year, and by the middle of December the work had been carried to main deck level. By the end of January, 1912, the concreting of the main deck was finished, and by March 9th, 1912, all the reinforced concrete work had been completed ; the beds for the engine and pumps, in plain concrete, were finished a week later. The watertight compartments were tested by filling them with water in May, 1912, and the pontoon was launched in the following month. No attempt was made to hasten the construction of this pontoon, and the time occupied in constructing it may therefore be regarded as typical for this class of structure.

Fittings.—The time required for fixing engines, machinery and other fittings is about the same as in steel vessels, but unless care is taken in designing concrete vessels a larger time may be required, owing to the greater difficulty in making alterations, such as the openings in the ship's bottom, stuffing boxes, the passage of pipes through bulkheads, the connection of fittings to the bulkheads and the connection of stancheons, fairleads, bollards, etc., to the deck. In a steel ship, if provision has not been made and holes punched to take any particular fittings, such as a bracket, before the erection of the bulkhead, it is an easy matter to drill holes afterwards to accommodate it. In a concrete vessel, however, the cutting of holes after the concrete has set is neither easy nor desirable, and it is therefore highly important that all the details of fittings required to be connected to the hull, or passing through a bulkhead, etc., should be considered before the erection and casting of that bulkhead, and the necessary information must be ready at an early stage of the construction in order that the builders may make suitable provision for the same when erecting the shuttering. The connection to the hull of the rudder post, stern post and the stern tube also present fresh problems in connection with concrete vessels. Such fittings as mooring pipes or hawser pipes, as well as the majority of small topside fittings, have to be specially designed, with proper projections for casting into the concrete, as otherwise holes must afterwards be cut to take the holding-down bolts. The facility with which these provisions can be made in concrete vessels is a great advantage, but, for the reason stated, it must not be deferred until the concrete has been placed.

The three to eight weeks required for the concrete to become sufficiently strong to permit the hull to be launched without undue risk is largely wasted, and constitutes an unavoidable loss of time which detracts from the rapidity with which the formwork can be re-erected and the reinforcement and concrete placed. Some of the time may be saved by launching the hull after three or four weeks, but not allowing the trial trip to be made for a further period of a month or more. Meanwhile, with discreet overseers, the fitting of the vessel may proceed immediately after launching.

Some time may also be saved by partially fitting up the vessel during the "weathering" period previous to launching, though most shipbuilders prefer to launch the bare hull. The longer the time after removal of the formwork the stronger will be the vessel, as concrete increases in strength in the course of time, whereas steel and wood begin to deteriorate the moment the vessel is launched.

WORKMANSHIP.

Speed in construction must on no account be sacrificed to excellency of workmanship in concrete vessels, or the consequences may be very serious. In steel or wooden vessels defective workmanship is revealed by leakage, but a concrete hull may be watertight and yet deficient in strength.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

A Treatise on Roads and Pavements—Concrete Roads and Pavements. By I. O. Baker, C.E., D.Eng.

London: Chapman & Hall. 3rd Edition. Price 21/- net.

The present volume differs in several important respects from the first edition, published in 1902, and the information appears to be quite up to date.

The volume is written chiefly for those engineers who are engaged in designing and inspecting roads rather than for the contractor who constructs them.

The section which deals specially with concrete roads and pavements is well written, though very little attention is paid to the chemical reactions which play so large a part in the setting and hardening of the cement and concrete.

The author is a firm adherent to the principles of proportion laid down by W. B. Fuller and described in detail in Taylor and Thompson's *Concrete* (1909), and considers the use of proportions of cement sand and coarse aggregate based on the voids in the two latter to be "not very practical." The proportions commonly in use are 1 : 2 : 3, 1 : 2 : 4, and 1 : 1½ : 3½.

He very rightly insists on the necessity of good drainage for the subgrade and for foundations, and maintains that these must be properly made, as "it is not wise to put any dependence upon the ability of the concrete slab to bridge soft spots." Special—almost elaborate care—is advised in the case of laying a concrete road or pavement on an old road bed so as to avoid it being cracked by variations in compactness and centering in the old bed. As he rightly states, the rolling of an old bed will not necessarily be sufficient preparation, as the roller may be supported on the more compact portions of the material and may never come into contact with the remainder.

The use of two courses of concrete—a cheap one below and a better one above—is regarded as unwise for several reasons (which are stated), and the detailed information is therefore confined to one-course work.

Very wisely, the author insists that the thickness of the concrete should be governed by the local conditions, and he therefore refrains from giving any definite ratios of thickness to width or radius of camber. In the Mississippi Valley the usual practice is to make the concrete 6 in. thick at the sides and 8 in. at the crown, but in the more arid States of California and Oregon roads with only 4 in. of concrete have given satisfaction.

The use of a soft concrete mixture is condemned, the most suitable consistency being such that the concrete will retain its shape when struck off with a template. A photograph is given on page 248 which purports to "show the proper consistency," but it is so small and is so arranged that it yields very little information. The same remark applies to a large number of the photographs which are reproduced in this volume; they are much too small to show the details essential to a proper understanding of the subject.

A well-deserved warning is issued against prematurely finishing the surface of the concrete. Before attempting to finish a road the concrete should be almost ready for the initial set and should be rolled or treated with a canvas belt by hand.

The great bugbear of the concrete road constructor—cracks—may be prevented by the inclusion of suitable contraction joints at regular intervals, about 50 ft. being the usual distance between them. The joints are preferably filled with 3-ply tar paper.

Reinforcement is regarded as undesirable in concrete roads unless the road is built on spongy soil, and only 5 per cent. of the roads in the United States are reinforced.

The characteristics of a good concrete road are said to be: reasonable first cost, low tractive resistance, good foothold, freedom from dust, and easy maintenance. Its chief fault is stated to be that its colour is trying to the eyes. Unfortunately, the author does not draw a sufficient conclusion of the relative advantages of concrete and other road materials.

The cost of concrete roads naturally varies with local conditions, the average rate of construction for country roads, exclusive of overhead expenses and profits, lying between 4s. and 5s. per sq. yd., the cost of maintenance being about one-fifth of a penny per sq. yd. per annum. The total cost of a concrete pavement in an American city, the pavement being 34 ft. wide and measuring 3,380 sq. yds., was found to be 2s. 6d. per sq. yd., exclusive of depreciation of machinery, superintendence and administration, the concrete being a 1 : 3 : 5 mixture.

Concrete curbs are recommended by the author in residential districts. The cost in America was found to be about 1s. 10d. per foot-run, of which 1s. 1d. is for labour and 9d. for materials. The author prefers to finish the face of concrete curbs by placing a flat spade vertically against the back of the form, pushing it at an angle of 20° or 30° and then withdrawing it, though the objections to using so soft a concrete are clearly recognised.

The cost of a combined concrete curb and gutter in America in 1916 was 2s. per linear foot. Its advantages are its cheapness, better and more permanent alignment and appearance, the concrete being more durable than a natural stone of equal cost, whilst, being smooth, it is easily cleaned.

Other well-known types of roads are dealt with in an equally clear and straightforward manner, the section on brick roads being particularly well written. This type of road, whilst very popular in the United States, is almost unknown in this country. It has proved to be remarkably durable when properly laid on a good concrete subgrade, the bricks being embedded with a suitable cement.

According to a recent official statement, the most durable road materials were the following, the figures indicating the percentage area of each in use in the United States: Macadam, 42; bricks, 21; stones, 20; gravel, 15; and concrete, 2 per cent. Hence, rapidly as the use of concrete roads is extending in the rural districts, a considerable time will be required before they can appreciably replace macadam and bricks.

Concrete Ships. By A. A. Boon.

Berlin: Ernst Sohn. 2nd Edition. Price 7 marks.

This small volume of 100 pages, by a Dutch engineer who has for some years specialised in this form of shipbuilding, is divided into three sections, of which the first deals with the advantages and disadvantages of concrete vessels and their cost, the second deals with the historical development of the industry in different countries, and the third and by far the most important section deals with details of the design of concrete vessels.

The author has made use of a considerable amount of the general information on the subject with which our readers are already familiar through the pages of *Concrete and Constructional Engineering*, and most of the illustrations he uses have already been published in our pages.

A short but interesting section deals with the covering of old boats with concrete, and thus making them seaworthy for an indefinitely long period. In this work the author has special experience and his suggestions are correspondingly valuable.

In the third section—on design and details—the author lays emphasis on the necessity of calculating correctly the minimum safe thickness of the shell in order to obtain the requisite lightness of construction. Scarcely sufficient attention has been paid to this by some builders. The arrangement of the beams and reinforcement to give longitudinal and transverse stresses are very briefly outlined, but for practical purposes the information given should be extended considerably and made to include much more detail. Particulars of actual vessels, properly dimensioned drawings, would have been much more valuable than the outline sketches published. This is particularly the case with the reinforcement suggested for the stems and sterns of the vessels on pp. 103-106.

Perhaps the most disappointing feature of the volume is the absence of any really useful information on the watertightness of concrete vessels. The author clearly considers that complete waterproofing may be obtained by skilful mixing of a suitably graded concrete without any other material. This is certainly interesting, but his statements would have been more convincing if explained in fuller detail.

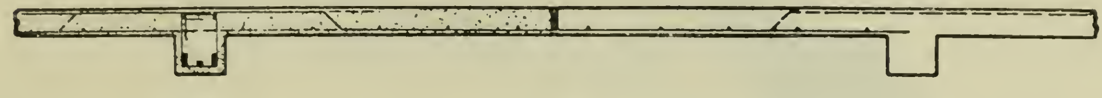
No index has been provided, so that reference is occasionally hindered, but as a whole the book should be very useful to those who wish to see what progress has been made in the construction of concrete ships during the past few years.

Hand Book of Instructions regarding Reinforced Concrete Structures.

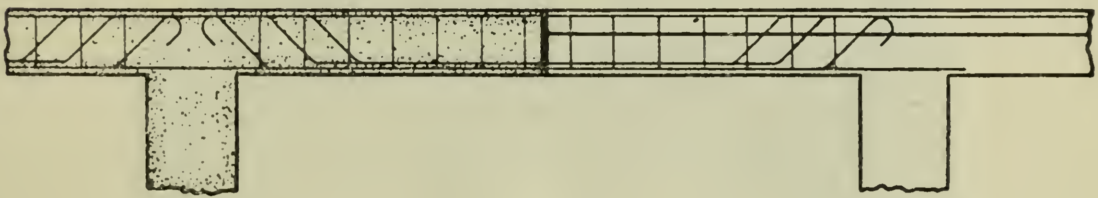
A very useful little booklet has been published by the Trussed Concrete Steel Co., Ltd., containing instructions for foremen or clerks of works engaged in the erection and inspection of reinforced concrete structures erected on their system. After some general remarks as to drawings and the duties of the inspector, the handbook goes on to deal in detail with centering, reinforcing steel, cement, sand, aggregates, the mixing of the concrete, proportions, placing of concrete, concreting in freezing weather, etc. Regarding the places for stopping concrete the writer of this publication makes the following remarks, which he illustrates in the following diagrams.

PLACES FOR STOPPING CONCRETING.

When concreting is once commenced it should be carried on vigorously to completion, if possible. If concreting must be stopped before the entire portion is completed, then the place for stopping should be determined upon as follows :—



SLAB



BEAMS

Method for Stopping Concreting.

For Stopping Slabs.—Stop the concrete at the middle of the span, making the plane perpendicular and at right angles to the direction of the span.

For Stopping Beams and Girders.—Stop concrete at the centre of the beam with a vertical plane at right angles to the direction of the beam.

In the foregoing and in every case there must be installed a sufficient number of continuity bars to tie the beam or slab to the opposite side. If there is no beam coming directly opposite the finished beam it should be well connected with the future opposite slab by means of steel.

In no case shall work be terminated on beams or floor slabs in any other places than indicated above without special permission from the engineer in charge of the work.

In no case shall work be terminated in beams or floor slabs where future shearing action will be great, as near the end or directly under any concentrated load.

In concreting columns, beams and slabs, if for some unforeseen cause the work must be stopped at places differently situated from those designated herein, the old surface must be roughened up and thoroughly covered with 1 : 1 cement mortar before concreting is continued.

Especial attention is drawn to the necessity for the greatest care in the removal of centering, and there are some useful notes on cement finish.

The booklet is one that should be in the hands of all who are in charge of reinforced concrete works, for whilst some of the sections apply quite especially to reinforced concrete work carried out on the Kahn system, there are other useful hints which would be general to all reinforced concrete work.

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

A NEW CONCRETE MOULDING MACHINE.

THE demand for a large number of cottages and small houses will lead builders to try different forms of construction with a view to ascertaining not only a rapid building method, but one which will enable them to build at a not too excessive cost. In this connection it is interesting to note the many new machines and systems of construction which are being put forward, and claim in a measure to assist in the solution of the problem.

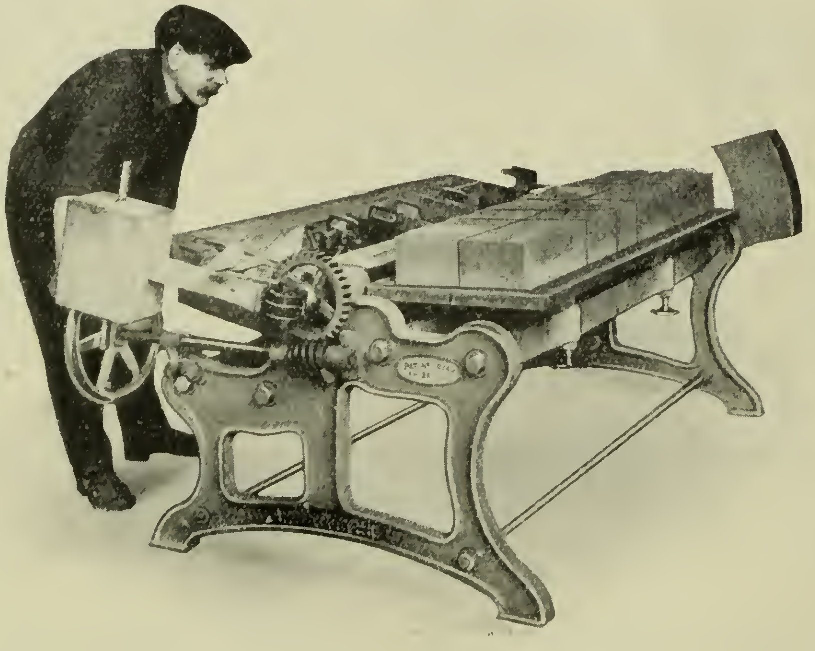


FIG. 1. Showing the Making of Blocks.

Recently a very interesting demonstration was given in the North of England of a new concrete moulding machine, on which, we are informed, every kind of stone can be made for a building from foundation to chimney.

The machine, which is very simple in construction and easy to manipulate, has a mould box which is cast in one piece and adjusted to the required sizes with special liners which are quickly placed in position.

When not employed for making blocks the machine can be used for making heads, sills, cornices, kerbs and channels, string courses, bases, mantels, shelves, etc., etc.

The capacity of the machine is stated to be 60 lineal ft. of finished stone per hour, and it will make anything up to 5 ft. long.

The blocks work out about two-thirds the cost of brickwork, and the makers state that no power is required to work the machine. It is light in weight. All.

the plates are of aluminium, and every machine is sent out with a complete outfit for making the various blocks and stones mentioned.

The accompanying illustrations show the machine in use for making blocks and cornice.

The makers of this machine are Messrs. R. H. Kirk & Co., Collingwood House, St. Peters, Newcastle-on-Tyne.

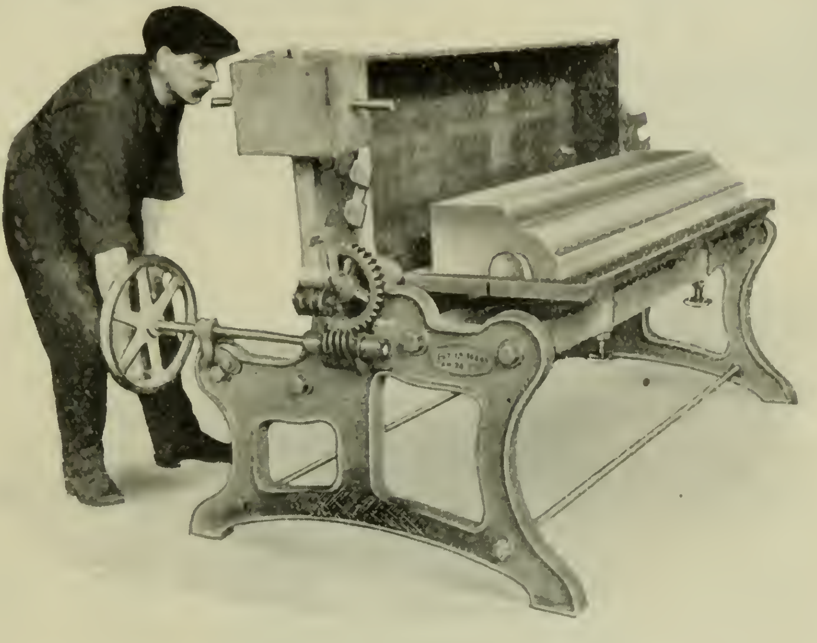


FIG. 2. A 5-ft. Length of Cornice.

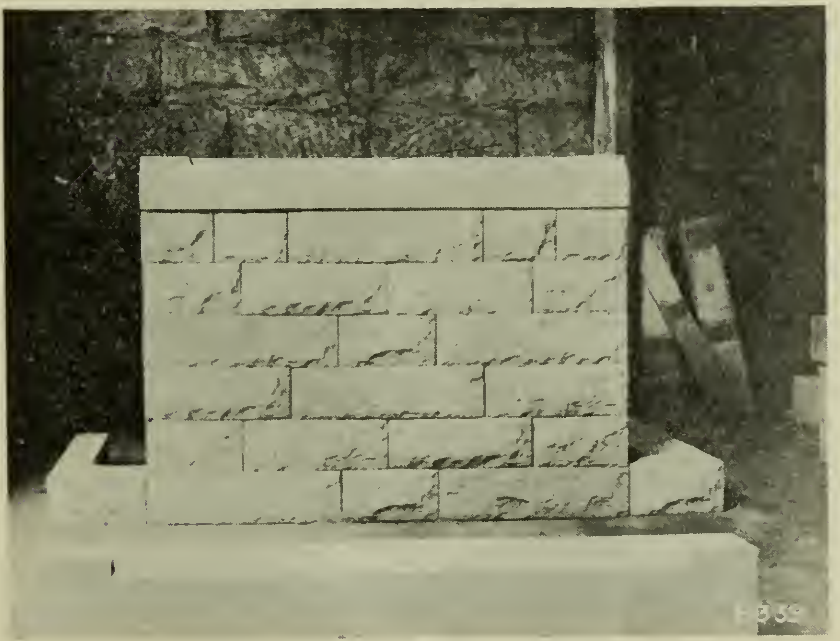
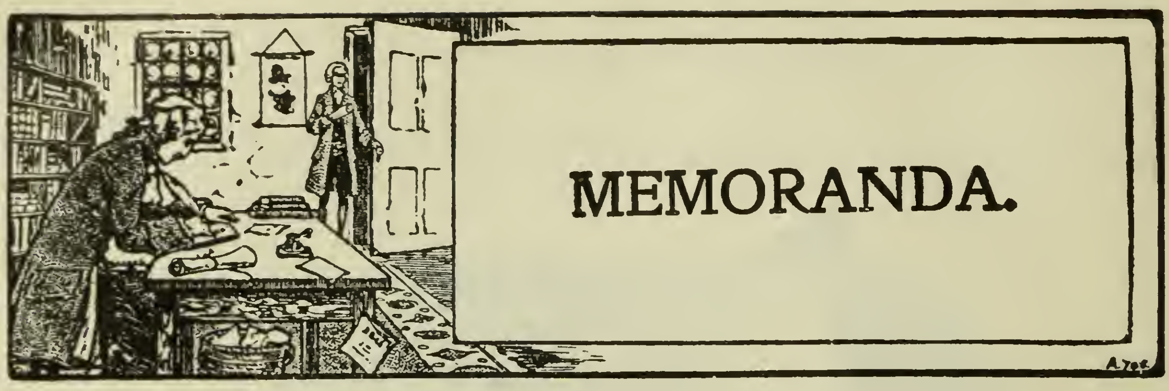


FIG. 3. Showing a window head and sill.
ROCK-FACED BLOCKS AND ROCK-FACED RETURN ENDS FOR GATE PIERS AND CORNERS.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Concrete Institute.—The Winter Session of the Concrete Institute will open on November 27th, when the Presidential Address will be delivered by Mr. H. D. Searles-Wood, F.R.I.B.A., F.S.I. The programme of the Session, as arranged at present, is as follows :—

1919 GENERAL MEETINGS.

Dec. 18. (Thursday) 7.30 p.m., 90th Ordinary General Meeting.
Paper by Mr. M. S. R. Adams on " The Use of Elliptical Vaulting as a Primary Factor in Contemporary Architecture " (Lantern).

1920

Jan. 22. (Thursday) 7.30 p.m., 91st Ordinary General Meeting.
Paper by Dr. J. S. Owens, F.R.G.S., F.G.S., etc., on " The Attrition of Concrete Surfaces, Exposed to Sea Action " (Lantern).

Feb. 26. (Thursday) 7.30 p.m., 92nd Ordinary General Meeting.
Paper by Mr. E. F. W Grimshaw on " Reinforced Concrete Fences and Posts."

Mar. 25. (Thursday) 7.30 p.m., 93rd Ordinary General Meeting.
Paper by Mr. E. Lawrence Hall on " Steelwork in the New London County Hall " (Lantern).

Apr. 22. (Thursday) 7.30 p.m., 94th Ordinary General Meeting.
Paper by Major Halstead Best, R.E., F.I.S.E., etc., on " The Mystery Port, Richborough " (Lantern).

May 27. (Thursday) 7.30 p.m., 11th Annual General Meeting.
95th Ordinary General Meeting.
Paper by Mr. E. L. Joseph on " Ventilation and Air-Purification as Applied to Modern Concrete Buildings."

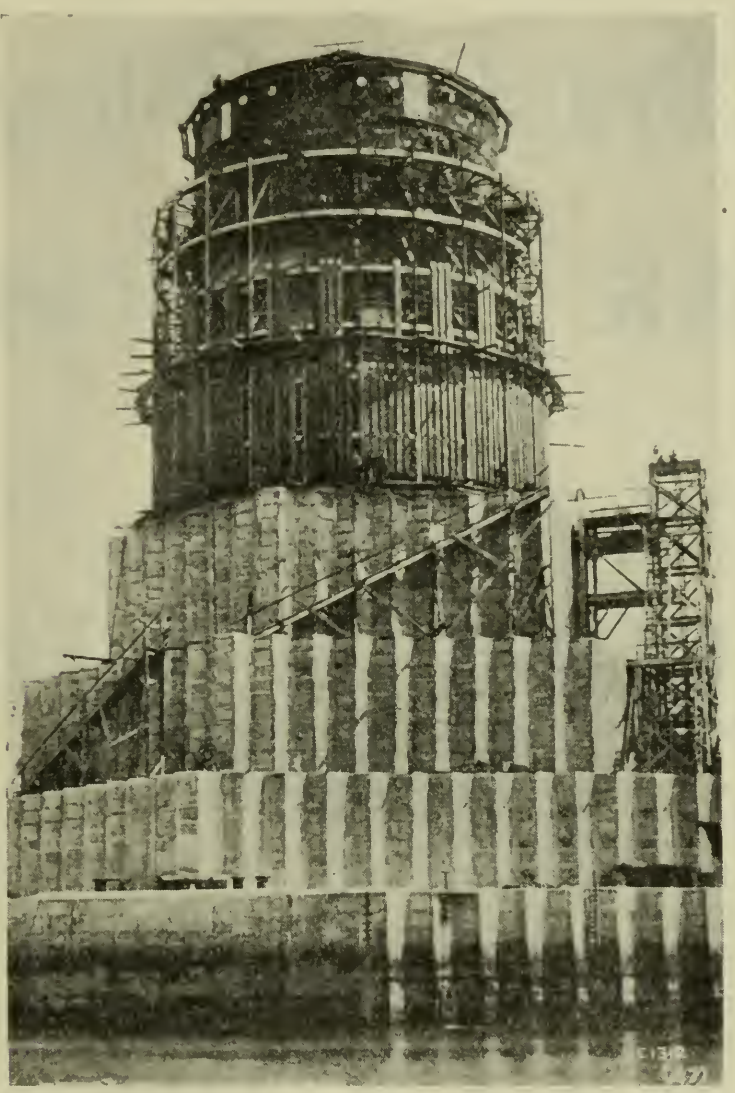
Housing.—The Linthwaite Urban Council have decided to enter into a contract with the Winget Concrete Company for the building of 14 houses at Cowlersley, with concrete blocks, as part of their housing scheme, at a cost of £785 per house. The scheme has been amended and approved by the Housing Commissioner.

Concrete Roads.—A correspondent in the periodical *Motor* contributes some interesting notes regarding concrete roads in America. He quotes from a letter received from California, which reads as follows :—

" I am now on an extended tour from the extreme south and probably ending at the north of California, all by motor. The motoring is very good, most of the main roads being concrete, and on which high speeds are possible and safe. There are long stretches perfectly straight with little traffic and practically no crossroads. One piece approaching Bakersfield ran for about 40 miles without a turn, and I nearly fell asleep driving. The Yosemite is a grand sight, a narrow valley surrounded by mountains straight up and down several thousand feet, but to get there was a task, as the mountain roads were narrow, twisting and very rough, and strings of cars going both ways up to the pass, nearly 8,000 ft.

"The State has just voted 40,000,000 dollars for roads, and before long the whole country will have a network of concrete roads. They build them wide enough to pass—18 ft.—but one has to be careful passing other cars at high speed, as off the track the road is lower and soft, and one easily swerves dangerously. People think little of runs of 300 miles a day. Oil and gas stations are strung along the roads, so that one has only to stop a few minutes and load up from the pumps. Petrol is called gas here and costs about 21 cents a short gallon, which is reasonable, even if 'Calif' is the greatest oil producer in the States." All this points to a rapid approach to ideal motoring conditions and accounts for the growing popularity of motoring in the States.

Concrete Towers on the South Coast.—In a recent issue we referred to some reinforced concrete structures which were being erected on the south coast, supposedly for the purpose of salving sunken ships, but the purpose to which they are to be put is not really known. The following illustration shows one of these structures. Each tower is in two parts, one of concrete and the other of steel. The concrete portion is about 100 ft. high, forms the base, and is in four tiers. It is composed of hexagonal cells made of reinforced concrete slabs, each cell being about 3 ft. in diameter. The tiers get smaller as they rise, but their size may be gathered from the illustration. It is understood, indeed, that the recess formed by the lower tier is larger than the Savoy Hotel ballroom.



The superstructure is a steel cylinder about 80 ft. high, with a space inside big enough to take a suburban villa. Work is still proceeding on these towers.

A Canvas Chute to Prevent Cement Dusting.—A Milwaukee contractor has recently employed a novel device to prevent cement dusting in connection with a

18,161 Tons of Steel Piling

AND

NEARLY 400 PLANTS

to drive it were supplied by

The British Steel Piling Co.

for

WAR PURPOSES

We are now accumulating our stocks of Piling and Pile Driving Equipment for

RECONSTRUCTION WORK

Make sure of being able to cope with your contracts on a profitable basis by making early application for the finest plant on the market, to

The British Steel Piling Co.

DOCK HOUSE,
BILLITER STREET, LONDON, E.C.3

concrete paving job on which bulk cement is being used. A 12-in. circular measuring chute, to the bottom of which is wired a hoop-weighted canvas chute, is employed, and when the cement is charged into a batch box the canvas extension is swung into the box, where the iron hoop holds it down, and then the gate is opened. When the charge has entered the canvas chute it is lifted, allowing the cement to run out gently and with no drop. It is then swung into the next batch box.

The cement chute, when not in use, can be swung to one side to be out of the way of the work and fastened in place.

Swimming Tank on Third Floor of Concrete Building.—A 120,000-gallon swimming pool, 27 ft. by 76 ft., on the third floor of the new eight-storey, reinforced concrete building of the Omaha Athletic Club, Omaha, Neb., necessitated unusual construction for the support of the tank and the support of the floors above it. This location was selected because it is within easy reach of the gymnasium and locker rooms, and all available space in the basement had been appropriated. As one row of interior columns is stopped at the third-floor level on account of the tank, the fifth floor is supported over the swimming room by heavy girders upon which are seated columns for the upper floors and roof, while hanger rods in these girders support the outer edge of a 4½-ft. balcony around the room at the fourth floor level. The depth of water in the pool is from 5 ft. to 11 ft.

The building is about 132 ft. by 118 ft. in plan, with eight floors and basement, together with two mezzanine floors beneath the third and fourth floors. The columns and footings are designed to carry two additional storeys. Normal column spacing is about 17 ft. by 15 ft., with corner panels 18½ ft. by 16¾ ft. Girders run onlyin the longer direction of the building, except in the end walls and at some special points. Spread footings of reinforced concrete on good yellow clay soil form the foundations. For those footings which support the swimming tank the load per square foot of base is limited to 3,500 lb.

The concrete tank is an integral part of the structural framing. Transverse girders 18 in. by 45 in. at the mezzanine floor below the third floor support the inclined bottom slab of the pool, which is 12 in. to 14 in. thick. The 12-in. walls are reinforced as cantilever slabs to resist the full hydrostatic pressure. As an extra precaution, vertical reinforcement was placed near the outer faces of these walls, thus making them act as supported slabs, designed for half the full water pressure. These slabs have a bearing on the bottom of the pool and on horizontal beams formed in the top rim, the beams bearing against buttresses or horizontal struts which deliver the thrust directly into the columns.

Waterproofing of the floor and sides of the tank is provided for by using a rich concrete mix of 1 :1½ : 3 with hydrated lime in the proportion of 10 per cent. of the weight of the cement. The pool is lined with three layers of asphalt and has a facing of ceramic tile. Severe tests of the structural and waterproofing features gave satisfactory results.

With the pool full the capacity is 120,000 gallons, giving an estimated weight of 500 tons. The bottom of the pool was designed to carry this load, 320 to 600 lb. per square foot according to depth, together with all dead load and an evenly distributed live load of 100 lb. per square foot. This live load represents the load superinposed by the swimmers in the pool and the waterproofing and tile finish on the bottom. In designing the members an extreme fibre stress of 700 lb. per square inch was allowed in the concrete and 18,000 in the steel high elastic limit. It was aimed to limit the deflection to 1/600 of the span for girders and slabs supporting the tank, since deflections which might be of no importance in an ordinary floor might tend to crack a tank bottom and cause leakage.

Moving a Reinforced Concrete Building to a New Site.—An interesting account is given in *Concrete*, U.S.A., of the removal intact of a three-storey concrete building across a street for a distance of 450 ft. It is stated that the business of the Hyatt Roller-bearing Co., which is occupying the building, went on as usual, and telephones, light and power connections were maintained by the use of extra lengths of cable from the transformer boxes, while entrance to the building was obtained by throwing a wooden incline from the temporary landing to the original ground surface as soon as the moving was temporarily stopped. This is reported as being the first time that a building of reinforced concrete frame construction with a brick facing has been moved.

Building Congress in Lyons.—A Building Congress is being held in Lyons this month at which the various questions relating to the housing question in France will come up for discussion. Among the questions to be discussed are cheap housing, the organisation of general constructional work, banks for co-operative enterprise, the result of the eight-hour day, etc.

PUBLICATIONS.

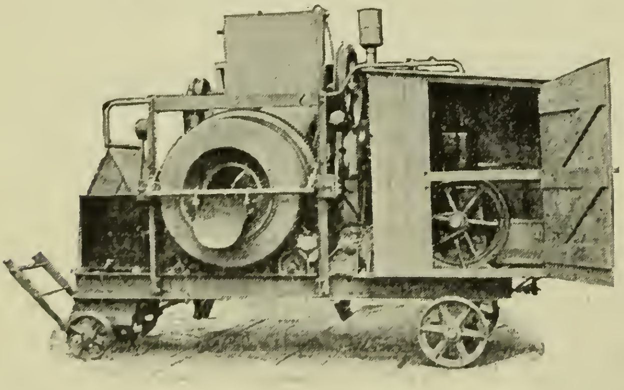
Engineering Industries.—We are asked to call attention to the pamphlet issued by the British Engineers' Association relating to import duties and the engineering industry. This publication can be obtained from the above association, whose offices are at 32, Victoria Street, S.W.1.

Checkweighing.—The Checkweighing in Various Industries Act received the Royal assent on August 15th, and came into operation on September 1st. Amongst other things, it relates to the getting of chalk or limestone from quarries and the manufacture of cement and lime.

A legal text-book explaining the new Act has been written by Mr. J. H. Cockburn, solicitor, Rotherham, author of "The Law of Coal, Coal Mining, and the Coal Trade." It will shortly be issued by Messrs. Stevens & Sons, 119, Chancery Lane, London.

PERSONAL.

Messrs. Brindley & Elbourne announce that they have now taken possession of their offices at 110, Victoria Street, S.W. 1, where they will practise as consulting engineers. Their principal activity will be to report and advise on factory reorganisation, with particular reference to production, efficiency, and co-ordination with Labour. The partners are H. S. B. Brindley and E. T. Elbourne.



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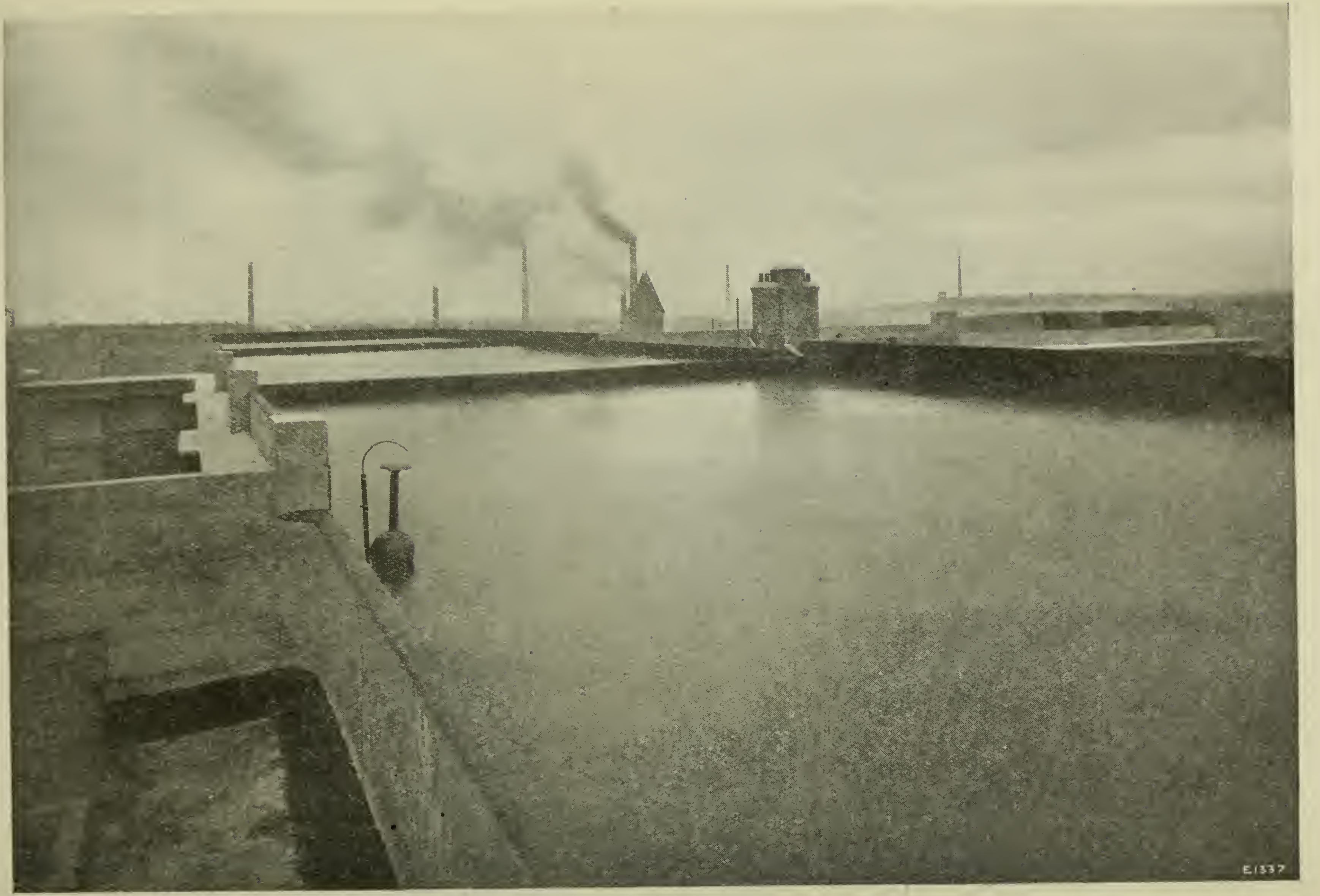


Reinforced Concrete Tank on the Roof of a Canteen.
(*For description see page* 631.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XIV. No. 11. LONDON, NOVEMBER, 1919.

EDITORIAL NOTES.

A STANDARD SPECIFICATION FOR ROADS.

THE recent railway strike has been responsible for many remarkable revelations, not the least being the fact that motor transport, which the average mind associated with the late war, has demonstrated its enormous possibilities as part of the national life in times of peace.

Before the evolution of this system can proceed unhampered a great deal of money will have to be spent in the improvement of our highways, in order that they may be strong enough to stand up under the grinding and pounding of motor traffic, and that they may present a surface which shall entail a minimum expenditure of energy on the part of the vehicles themselves. As our readers are aware, it has always been our contention that the concrete road is the one which will be found to meet these new demands most completely.

The efficiency of the concrete road is a subject to which reference has been made in this journal too frequently to need any recapitulation, but the fact that some 10,000 miles of this form of construction have been laid in the United States alone is significant. In the fourteen years during which this work has made steadily increasing progress a vast amount of experience has been acquired, resulting in improved methods of which the various local authorities in America are not slow to take advantage, and we hear month by month of large sums of money being voted in various parts of the States for the construction of concrete roads.

The Ministry of Health Housing Department has recently issued a " Standard Specification for Roads and Sewers." It is stated on the title page that " this standard specification is intended to apply only to residential roads on which heavy traffic is not anticipated." and that " for roads carrying heavy traffic a more substantial construction may be necessary."

The specification consists of two parts : I.—Materials ; II.—Road Construction. Concrete is certainly mentioned in Part I., but since in Part II. the concrete road is not included it is to be inferred that the concrete specified in Part I. refers to sub-grades only, especially as the proportion given is 6 : 1, which, as experience has taught, is quite inadequate for a one-course concrete road, and its adoption only invites failure. This omission is to be regretted.

In view of the success claimed for the American concrete roads we are of opinion that the time has come for our own Government to consider the issue of a standard specification for such roads in this country, and to this end we respectfully suggest that they send a properly constituted Commission to study the question in the United States and Canada. If, after full and impartial investigation, it be found that the claims of the concrete road cannot be substantiated, well and good, we shall, at any rate, know where we are ; but if they prove to be as efficient as they are stated to be, it is to the public interest that they should be officially recognised and given the opportunity of proving their worth in this country on the great highways, in residential roads, and in the busy thoroughfares of our industrial centres.

THE HOUSING SCHEME.

THE delay in making any real progress with the erection of the houses which are so urgently needed is becoming more serious every day, and unless the question is handled in a more efficient manner by the Government it will take at least ten years before the present deficiency is made up. Various statements were made when the Armistice was signed twelve months ago as to the scheme for erecting three hundred thousand or half a million homes in one year, and we look around in vain to find three hundred new homes erected under the national scheme, or even any real indication that the dwellings will be provided in a short time. What is the position to-day ? A certain number of schemes have been approved and are in hand which will produce about sufficient houses to meet the normal twelve months' demand in pre-war days, and thus it can be stated that *nothing* has yet been done to make up the serious deficiency that existed when hostilities ceased. Furthermore, several local authorities have obtained tenders and then abandoned their schemes altogether, and public money and time have been entirely wasted.

WOODEN HOUSES.

At the eleventh hour comes a demand for wooden houses, and a great controversy arises which ends in a semi-approval of the Ministry of Health on the understanding that the local authorities must first be approached and their approval obtained, but if this is withheld recourse may be had to a direct application to the Ministry. The great recommendations put forward by advocates of wooden houses are (*a*) the speed of erection and (*b*) the saving in initial outlay. Now the attitude of the Ministry of Health is such that any gain in the speed of erection will be quite lost at the outset owing to the time that will be taken up in dealing with local authorities who are likely to prove awkward and the possible submission to the Ministry direct. No one cares to embark on a scheme and go to the trouble and expense of getting out drawings and specifications for a type of building which is almost certain to be rejected, and thus it will prove infinitely quicker and more satisfactory to adhere to established practice unless some different arrangement is made which will place the organiser in a secure position.

As regards the saving in initial outlay, we are doubtful if this is likely to be quite as large as many persons consider. In the first case timber is demanding a very high price, and if many buildings are to be entirely erected with this material the demand will exceed the supply by such a large margin that prices will go still higher. As mentioned in these notes in our last issue, a general note is given in the standard specification for cottages to the effect that, in view of its present scarcity, timber should not be used when other materials of equal or less cost and of equal efficiency can be substituted. This can hardly be reconciled with Dr. Addison's remarks on October 15th, before a conference at the Ministry of Health, "that you cannot get wooden houses cheaper. I wish someone would come along and offer to build them for us. But it cannot be done." It will be noticed that no reference is made to the scarcity of timber but only to the question of price.

COMPARISON WITH AMERICAN CONDITIONS.

A very strong point in favour of wooden houses has been made by various persons that what is suitable in America must be suitable in this country, but upon investigation it will be found that this contention is hardly correct. In building wooden houses the Americans are merely taking advantage of the natural resources of their country just as we should use all the resources of our country if economy is to be effected. All the timber required for the proposed wooden houses will have to be imported, whereas by the use of concrete or bricks we should save our shipping for other purposes, and keep so much more money in the country. Again, many of the wooden dwellings erected by the Americans are the outcome of what may be termed pioneer work in comparatively new settlements, and in many districts the permanent and more modern houses are constructed with concrete, brick or stone, which materials are becoming daily more general. On one large estate near Columbus, Ohio, which is being developed on garden city lines, there are practically no frame buildings, and many of the structures are modelled on the best types of modern English houses, both as regards design and construction. Many frame houses are still being built in America, and this is, of course, natural and good policy, because timber is plentiful and in harmony with the surroundings. The conditions are also very different in America, where estates are being developed because the ground landlord is practically unknown. The land is laid out in suitable plots, the sewers, gas and water mains are laid, and roads are made and the plots are then sold outright to the person intending to build. In many cases the plots are bought and cultivated as allotments until the owner, probably a working man, is in a position to commence erection, and then building operations are started. In a frame building considerable labour can be done by the owner himself, and the general construction can be carried out without the use of extensive plant and in a minimum of time. The majority of the houses are detached ones or semi-detached, and a material which is suitable for these conditions cannot be advocated for groups, where the fire hazard is great.

The conditions generally are therefore very different in America to what they are in this country, and the wooden house, which is a natural development in the former, is alien to this. If wooden houses were to be built in this country they should have been erected months ago to relieve temporarily the shortage in those districts where the situation was most acute, and they should not be considered as a solution of the difficulties—made chiefly by red tape—at the eleventh hour. As we have previously stated, no material should be disqualified entirely, but advantage should be taken of all and every material which is available, and if all our resources were intelligently applied there would be sufficient to keep all the men in the building trade employed on the housing scheme.

COST OF BUILDINGS.

The difficulty as regards the present cost of building work is one which cannot be easily and entirely overcome, but the point that appears to be so thoroughly overlooked is that money has quite a different value to what it had in pre-war days. The cost of building has advanced fully 100 per cent., but wages have also advanced in a similar manner, and there is therefore no reason why the rental values of buildings should not be increased *pro rata*. When the difference in money value is properly appreciated and due allowance is made in a consistent manner, much of the difficulty now arising through housing schemes will disappear.

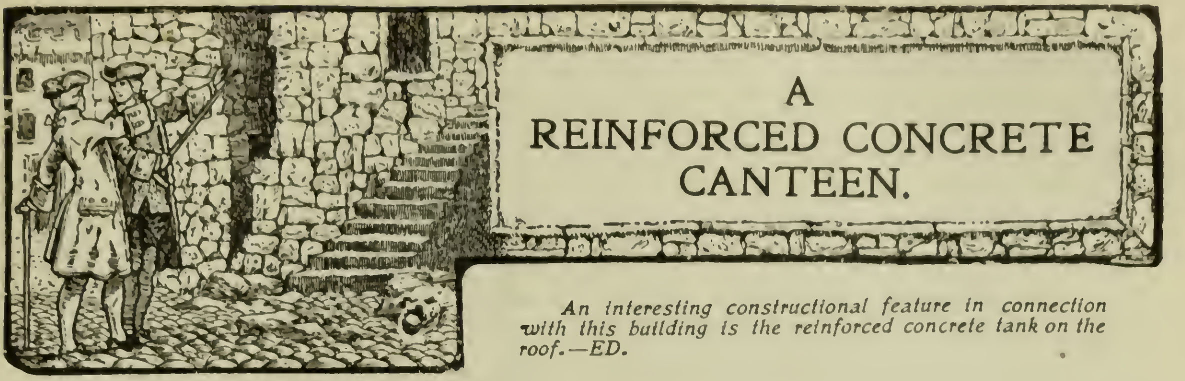
CONCLUSION.

Efforts should be made to use all materials which are at all suitable for dwellings, whether it be brick, concrete, stone or timber, and each locality can provide some portion of the material required. The Birmingham City Council state that they can build brick houses more cheaply than concrete ones, and if this is the case they should use brick, although we doubt if the comparison is the outcome of a real effort to use the most suitable material. In some districts a combination of asbestos sheeting and mass concrete has proved economical, and in others the use of concrete blocks has resulted in economy, and thus much depends on the skill of the designer and the materials at hand which are available. The great consideration is to build, and build quickly, and all red tape and unnecessary restrictions should be swept aside in order that suitable homes may be quickly erected.

REINFORCED CONCRETE TEST.

It is seldom that an opportunity occurs for a really severe test on a reinforced concrete building, and great value is therefore attached to the report, which we publish in this issue, on the test which was conducted on a flat slab floor in the Western Newspaper Union Building in Chicago in 1917. As the building was to be demolished to clear the site of the new Union Passenger Station it was possible to apply an excessive load without any regard to the damage that would result to the structure itself, and thus exceptional records could be taken. The information obtained will have an important bearing on the design of the flat slab structure and the action of the floor under the test should give added confidence in the suitability and reliability of the flat slab as a load-carrying structure. This type of construction is widely adopted in large industrial buildings in America, and considering the economy of the system it is surprising that it has not been generally adopted in this country.

Attention may also be called to the method employed by the contractor for wrecking the building, which was nine years old at the time of demolition. Much speculation has been made as to the difficulty of pulling down reinforced concrete structures if such a necessity should arise, and the method adopted in this instance is noteworthy for its simplicity and effectiveness.



A
REINFORCED CONCRETE CANTEEN.

An interesting constructional feature in connection with this building is the reinforced concrete tank on the roof.—ED.

A VERY good example of the use of reinforced concrete is provided in the canteen erected for Messrs. Leyland Motors, Ltd., and the whole building is indicative of the efforts which are being made by all the large progressive firms to provide for the comfort of their workers during their leisure moments, as well as during working time. It is now fully recognised that proper attention to the welfare of the employees will result in better production, and thus the employer will benefit by the investment of a certain amount of capital in this direction, besides which he will be in a better position to retain his labour during times of general shortage. This building is of considerable size, the main portion measuring about 242 ft. by 50 ft. wide, and the wing portion being about 70 ft. by 50 ft. The ground floor is allocated to lavatories for men and women, cloak rooms, time offices, cycle storage, and cold stores for food-stuffs. The first floor is equipped as a dining hall, and the second floor is fitted up as an experimental workshop with all the most modern equipment. Originally, alternative designs were made for a steel-framed building with concrete floors and brick walls, but the estimated cost was higher than that for a reinforced concrete frame building with 11-in. brick cavity wall panels, and the latter method was therefore adopted. The use of the reinforced concrete construction also meant a saving in maintenance, cost, and greater security in case of fire. The general lay-out of the constructional members is given in *Figs.* 1 and 5, which show the cross-section and first floor plan of the building; and on reference to the former it will be noticed that a tank is provided on the roof which is described hereafter.

The width of the building is divided into three bays, by two interior lines of columns spaced at about 16 ft., while the longitudinal spacing is about 12 ft. 6 in. Columns are also provided in the external walls so that a complete reinforced concrete frame was formed. The foundations to the columns were carried down to a depth of 5 ft. below the ground floor level, and were formed with reinforced concrete bases about 5 ft. 6 in. square. The height of the ground floor is 11 ft. 6 in. and the columns are 14 in. square in the interior lines, and 12 in. square when occurring in the external walls. The first floor has a height of 17 ft. 6 in. to obtain a good proportion for the large dining hall, which is well illustrated in the photographs in *Figs.* 3 and 4. One of the chief features in the hall is provided by the reinforced concrete columns which are circular on plan, and have a diameter of 14 in. with a moulding and enlarged cap at the intersection with the beams of the second floor. These columns add greatly to the appearance of the room and are specially suitable because a raised stage is provided at one end of the hall so that it can be used for entertainments when not required for dining purposes. Circular work of this kind is usually expensive, but in this case economy was obtained by the use of Hy-rib sheathing, which, by forming a mould for the concrete, dispensed with the necessity for any timber shuttering or false work, and in addition, provided reinforcement. Further reinforcement was achieved by the introduction of four vertical ⅝-in. Kahn rib bars, and one ⅜-in. rod. After the columns had been cast they were plastered with Portland cement plaster, applied to the outside face of the Hy-rib sheathing. The wing portion of the building is fitted up as a kitchen (*Fig.* 2) with electric and steam cooking apparatus of the latest type, and here the columns were made 12 in. square as this form was more suitable, and no special appearance was required. The second floor has a height of 14 ft. 6 in., and the columns are 10 in. square in the interior lines, and 12 in. by 10 in. in the outer walls. The floors, generally, are constructed with 3½ in. or 4 in. reinforced concrete slabs reinforced with ⅜-in. rib bars at 9 or 10 in. centres, and having ¼-in. diameter distribution rods at 12 in. centres. In the main building these slabs have a span of about 6 ft., and they are carried by beams 15½ in. deep, and 6 in. wide, which run across the width of the building at each column, and in the centre of the space between, the span being thus about 16 ft. The main beams, which have a span of about 12 ft. 6 in., and which run parallel to the length of the building, are 17½ in. deep by 6 in. wide, and in addition to the main reinforcement, short ⅜-in. rib bars are provided in the upper surface of the slab at right angles to the length of the beam, as the latter was calculated as a tee-beam.

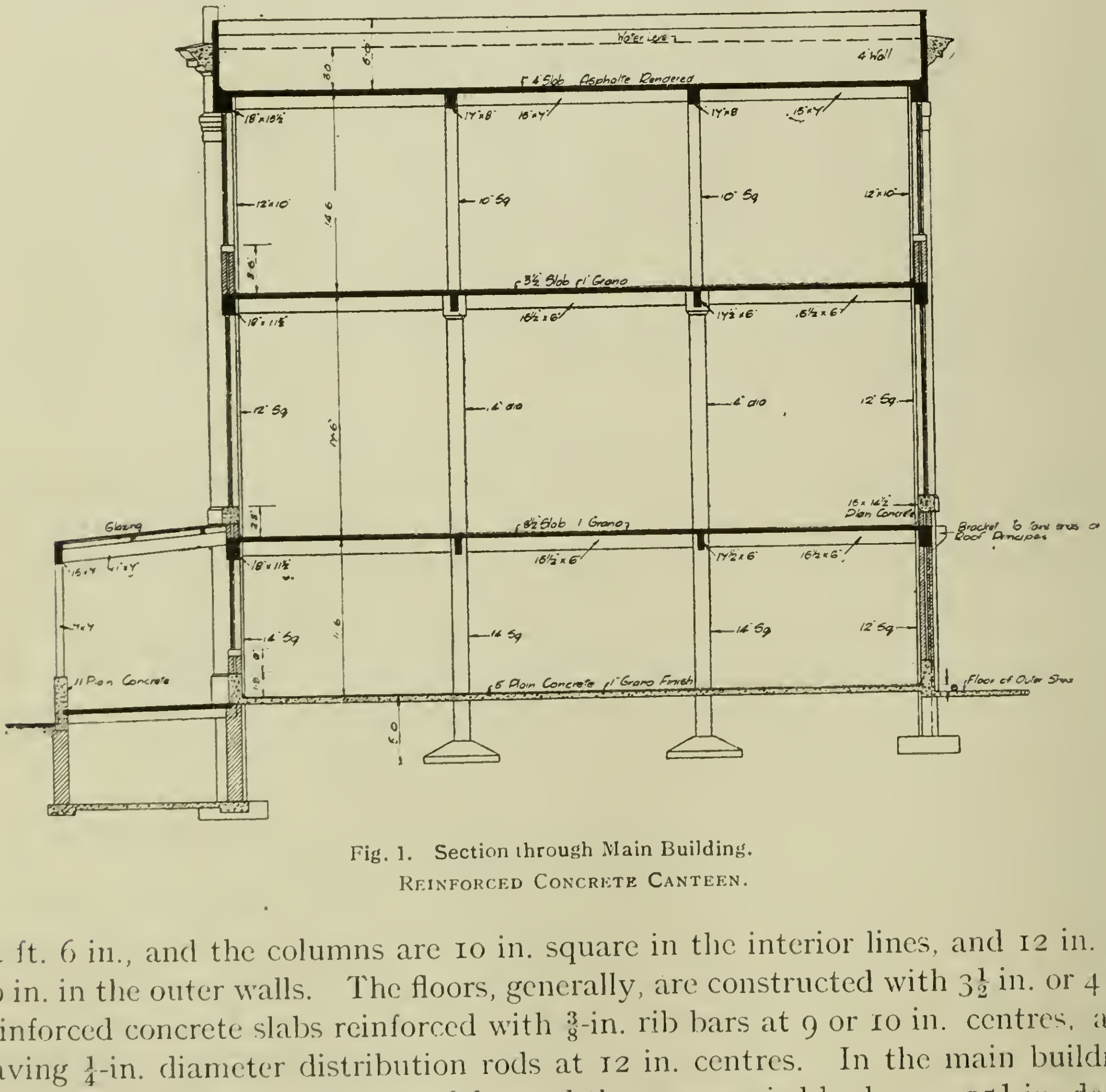


Fig. 1. Section through Main Building.
Reinforced Concrete Canteen.

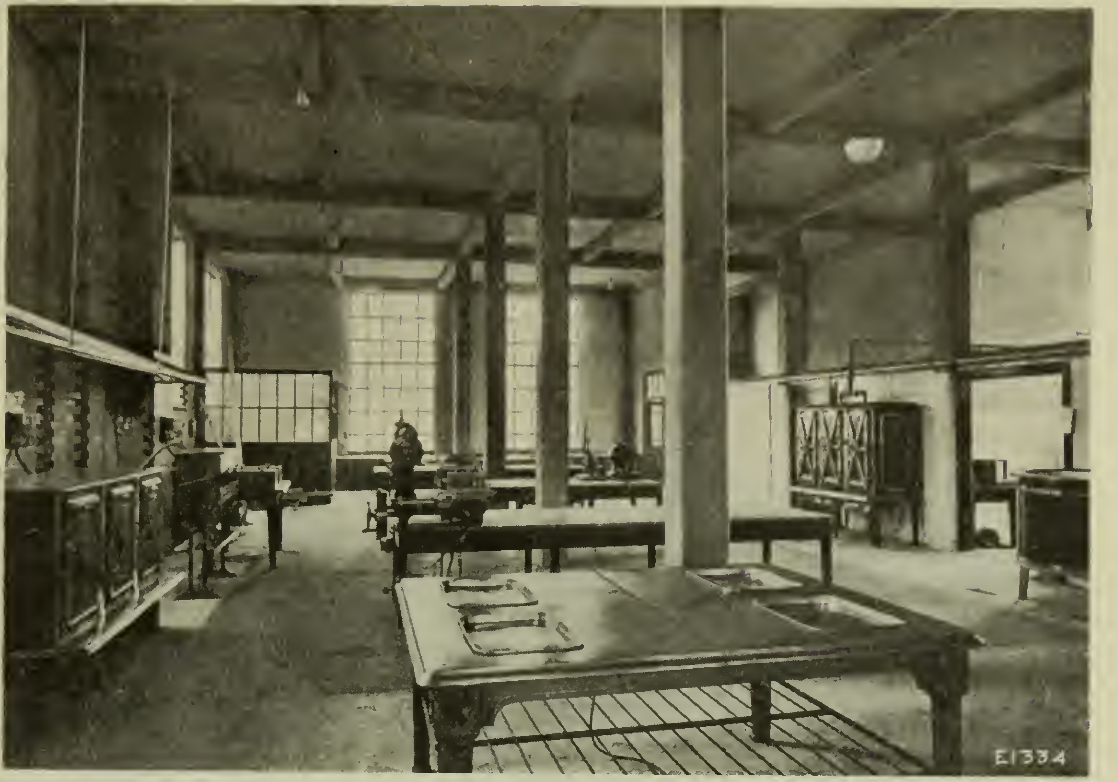


Fig. 2. The Kitchen.

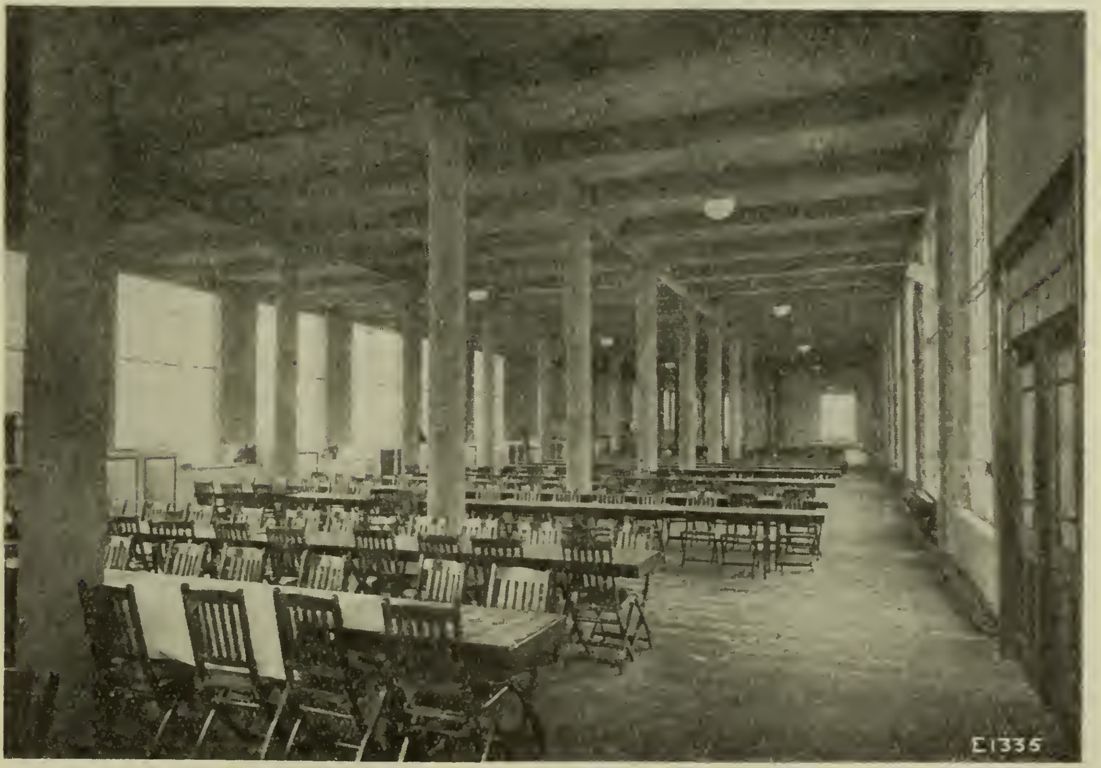


Fig. 3. The Dining Hall.

A Reinforced Concrete Canteen.

Similar bars are also introduced in the beams which occur in the walls in order to give an effective ell section. The four staircases that were provided were constructed in reinforced concrete.

The tank on the roof is an interesting example of the utility of reinforced concrete construction, as the floor of the tank is formed by the roof constructed over the second floor, and by carrying up the parapet walls to give satisfactory architectural effect a large space is provided which is turned to good account with a minimum additional cost. The slab which acts as the bottom of the tank is 4 in. thick, and the whole of the interior is lined with asphalt. Interior division walls were provided at various positions, and these are 4 in. thick, reinforced with $\frac{3}{8}$-in. rib bars, in both directions with additional concrete and diagonal bars at the intersections with the external walls and the floor. The external walls are formed partly by the reinforced concrete cornice, which is kept above the general roof level, and partly by a parapet wall 4 in. thick, which is constructed above the cornice. This cornice is formed with bold mouldings on the outside with a splayed top to throw off water, and it has a projection of about 24 in. It is reinforced with three lines of longitudinal $\frac{5}{8}$ in. rib bars in the projecting portion around which are carried $\frac{1}{4}$-in. diameter profile rods at 12 in. centres, extended back to the inside face of the wall, where they are hooked to $\frac{5}{8}$-in. rib bars, which form part of the inner reinforcement. The cornice is also anchored back to the beams below by $\frac{3}{8}$-in. rib bars which are cranked as required from the heart of the former to secure good adhesion. The storage capacity of the tank is nearly 208,000 gallons of water, weighing about 928 tons ; and thus, it will be seen, that good use has been made of what is so often waste space on the roof. A plan and some

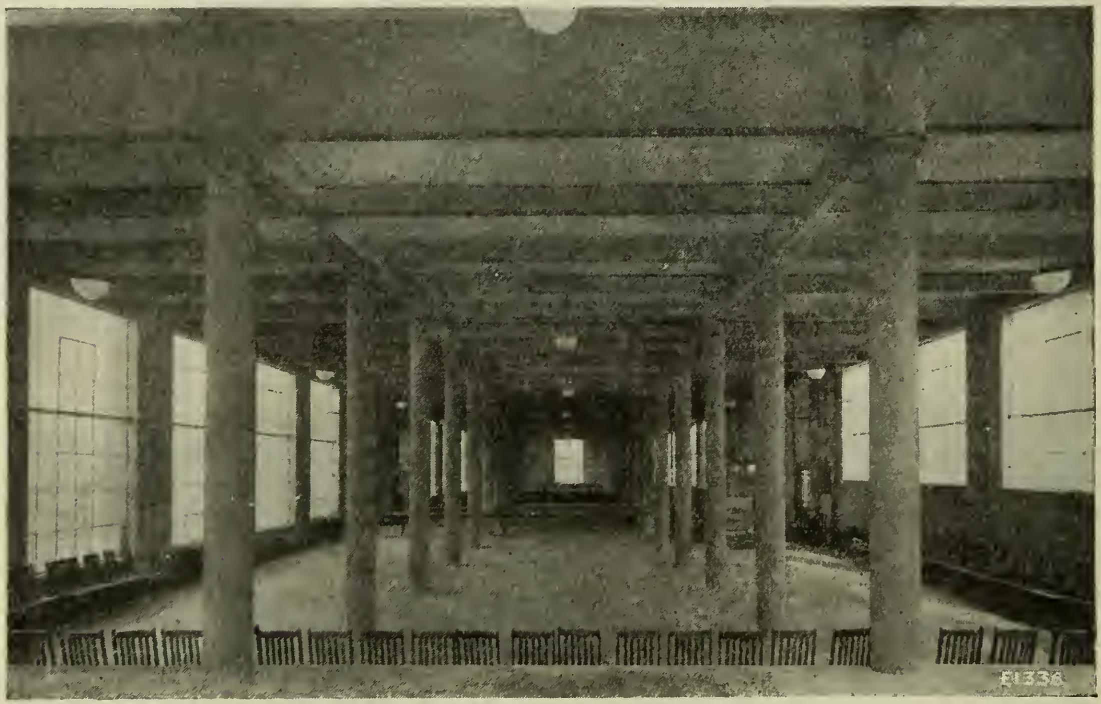


Fig. 4. Another View of Dining Hall.
A Reinforced Concrete Canteen.

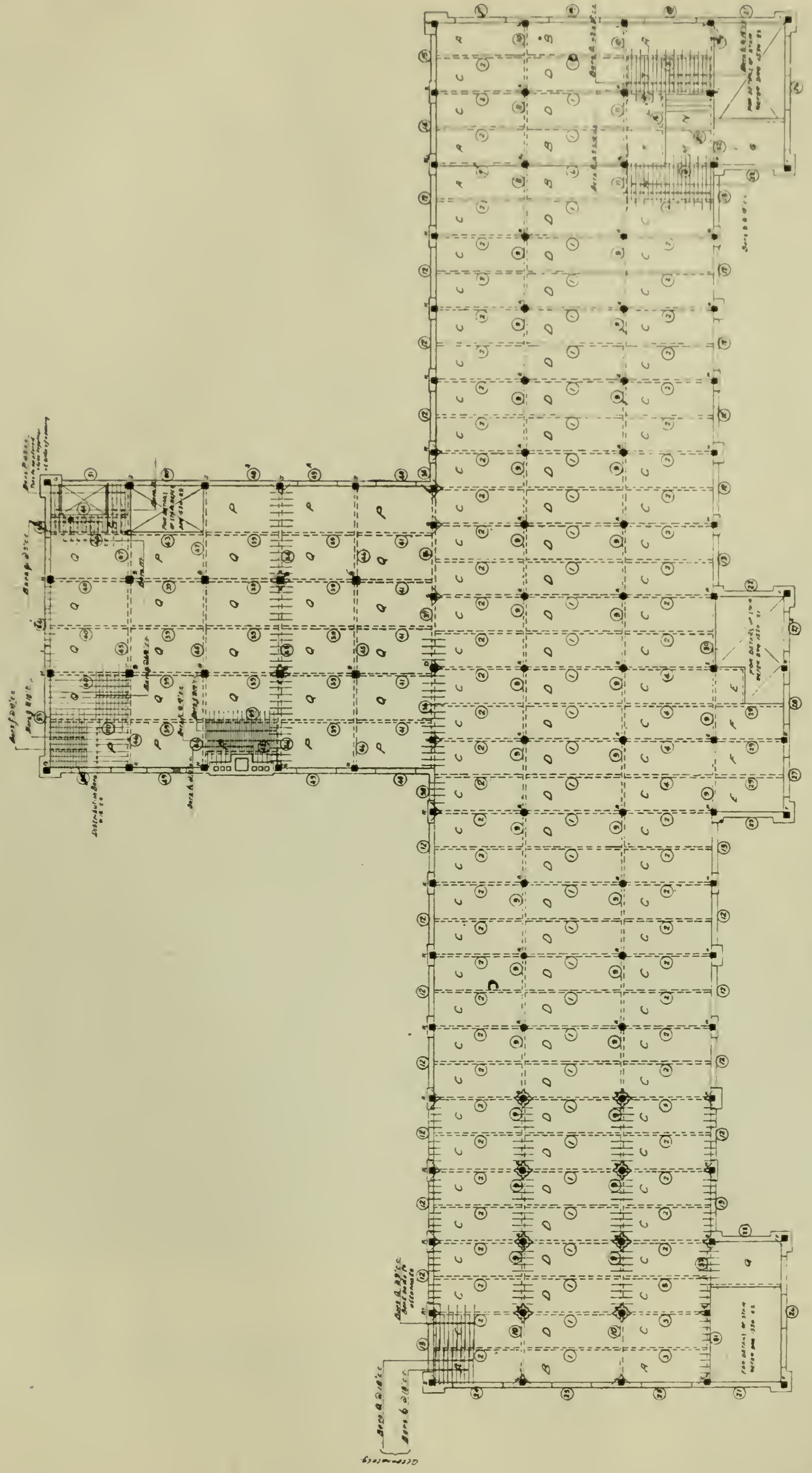


Fig. 5. First Floor Plan—showing second floor construction.
A Reinforced Concrete Canteen.

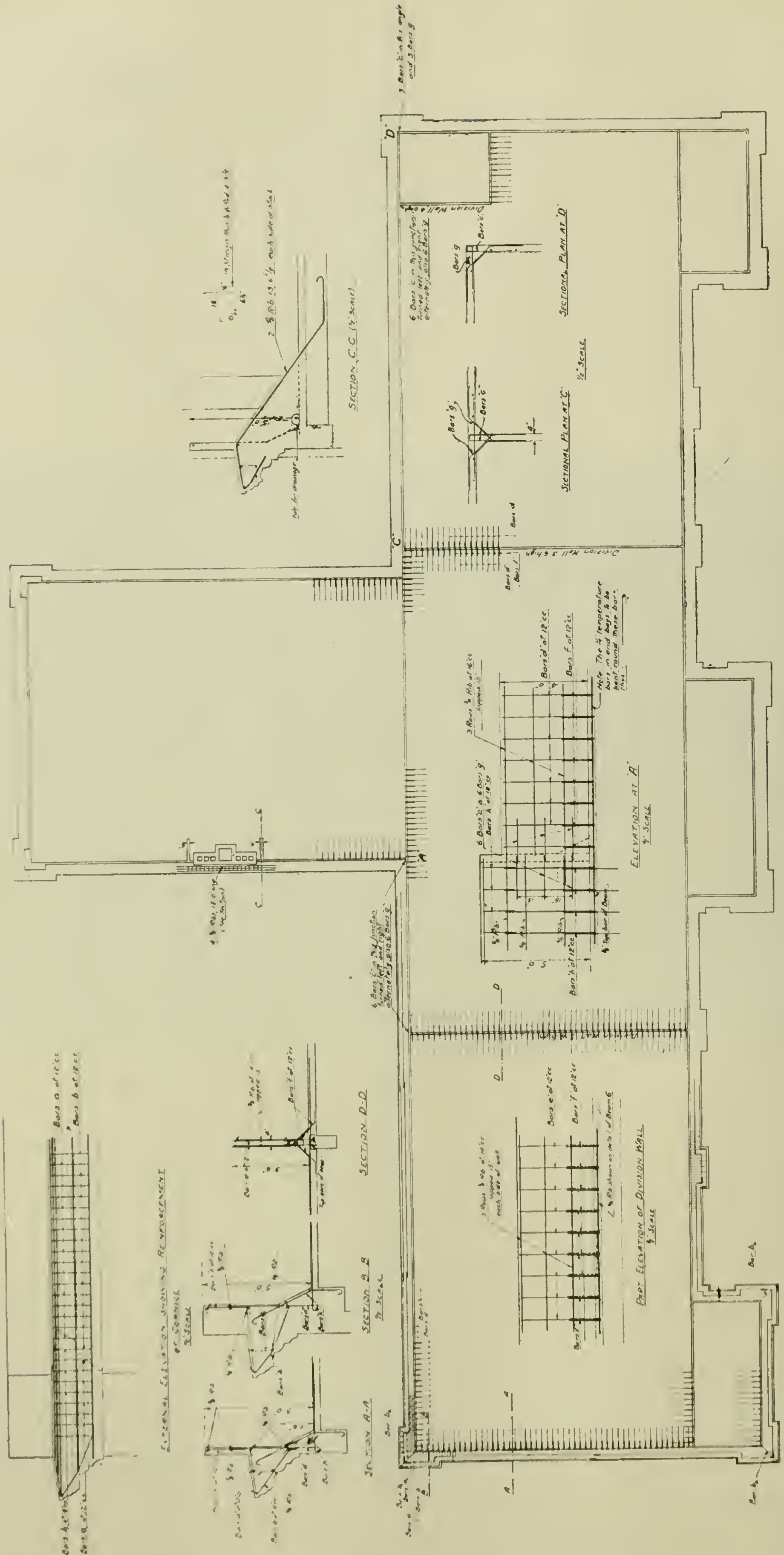


Fig. 6. Mess Room Roof—tank walls and parapet walls

A Reinforced Concrete Canteen.

details of the tank construction are shown in *Fig.* 6, while the photograph on the frontispiece shows the completed tank filled with water. The general appearance of the building externally is shown in the photograph in *Fig.* 7, and it will be seen that a good effect is obtained by the bold cornice and the pilaster treatment of the walls, and the proportions generally are quite successful. The building is heated throughout by low-pressure hot water pipes and radiators, the water being heated in calorifiers supplied with exhaust steam from the works. The partitions were formed with Hy-rib, and grooves 2 in. by 1½ in. were left in the concrete floors, ceilings and columns, to receive these. The floors are finished with wood blocks laid on to the reinforced concrete slabs, and the windows are fitted with steel sashes.

The work was carried out from designs prepared by, and under the supervision of, Major O. M. Bluhm, A.R.I.B.A., architect, of St. Annes-on-Sea, Preston and Manchester, and the engineers for the reinforced concrete work were The Trussed Concrete Steel Co., Ltd., South Kensington. The general contractors were Messrs. S. & J. Smethurst, Ltd., Oldham.

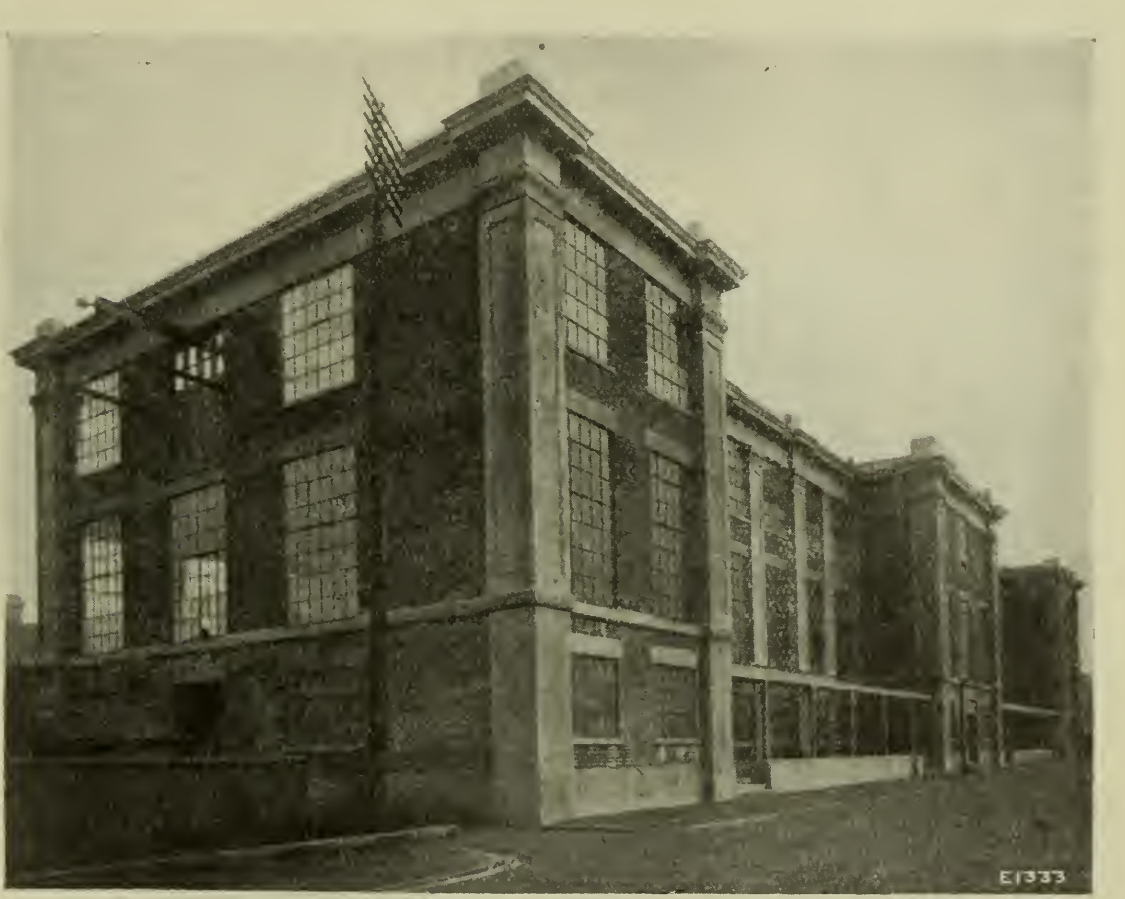
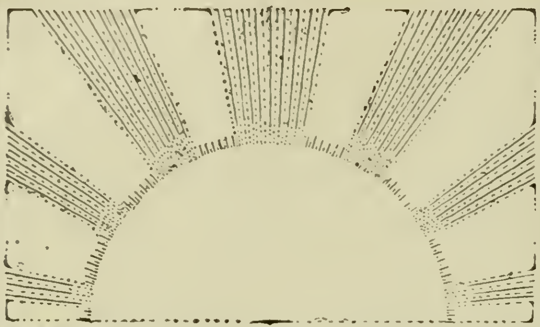


Fig. 7. General View of Completed Building.
A Reinforced Concrete Canteen.



THE ADVENT OF CONCRETE ROADS IN THE METROPOLITAN AREA.

We publish below an account of the construction of certain concrete roads in the London district. The engineers responsible for these roads, together with their Councils, are to be congratulated upon their enterprise, and it is hoped that the success which has attended their efforts will act as a stimulus to other local authorities. That concrete roads should be given a fair trial in this country is all we ask; in the result we have every confidence.—ED.

In spite of insular prejudice and national conservatism the concrete road has at length made its appearance in the metropolis.

From letters which we receive, and from discussions which take place in the public Press and in meetings of various bodies interested in road construction, the prevailing opinion would still appear to be that the concrete road is yet in its experimental stage. While admitting that we have much to learn in concrete construction generally, and with regard to concrete roads in particular, we can assert with confidence that the concrete road has long passed out of the region of experiment, and has more than justified itself as a sound method of construction.

The present article deals with the concrete roads which have been laid in two boroughs in the metropolitan area, where the borough engineers have had the courage of their convictions and, with the consent of their respective councils, have carried their ideas into effect.

SOUTHWARK.

Mr. Arthur Harrison, M.Inst.C.E., the borough engineer of Southwark, has long been convinced of the value of the concrete road, and under his recommendation a stretch of concrete roadway was laid as an experiment in Penton Place in August and September, 1918. The success of this having been assured, the Southwark Borough Council laid down a programme for nine concrete roads, of which six have now been completed.

The general method adopted is the same for all, although Mr. Harrison states that each street laid taught them something new, and that, therefore, the whole scheme so far has been one of continual progress, each road being an improvement in various small details upon the one previously laid.

Construction.—The original roadway was of granite macadam, and this was excavated to a depth of 9 in. The foundation, which was found to be fairly solid, received no special preparation, and after being rolled was ready to receive the concrete.

The two-course method was adopted, the lower course being 4 in. thick and the wearing coat 2 in., the latter being laid before the former had set so that the whole might form one monolithic structure. The concrete for the lower consists of a 6 : 1 mixture, and the material from the old macadam road was used as the aggregate.

The upper course is composed of a 3 : 1 mixture, the aggregate in this case also being the material from the original road, washed, crushed and graded to ¼-in. down.

The reinforcement is placed 2 in. from the bottom, *i.e.*, in the middle of the bottom course. It consists of ⅜-in. rods simply interlaced, like bedstead laths and wired at the ends, successive lengths being joined to each other by being hooked together.

The method of laying alternate sections is not adopted, but each day's work is finished off by a clear vertical edge as shown in *Fig.* 1, against which the next day's work is butted without the intervention of a joint filler of any description. The reinforcement does not extend over these joints, so that each section consists of a slab of reinforced concrete in itself.

The contour is formed by the use of pins which are removed as the work proceeds.

For finishing the surface, Mr. Harrison has devised a special tool, which consists of a metal plate 15 in. sq., to which is attached a handle fixed obliquely so that the tool can be operated from the side of the road. The surface is rubbed over with this tool, and parts of the road which are found to be too smooth are roughened with a bass broom.

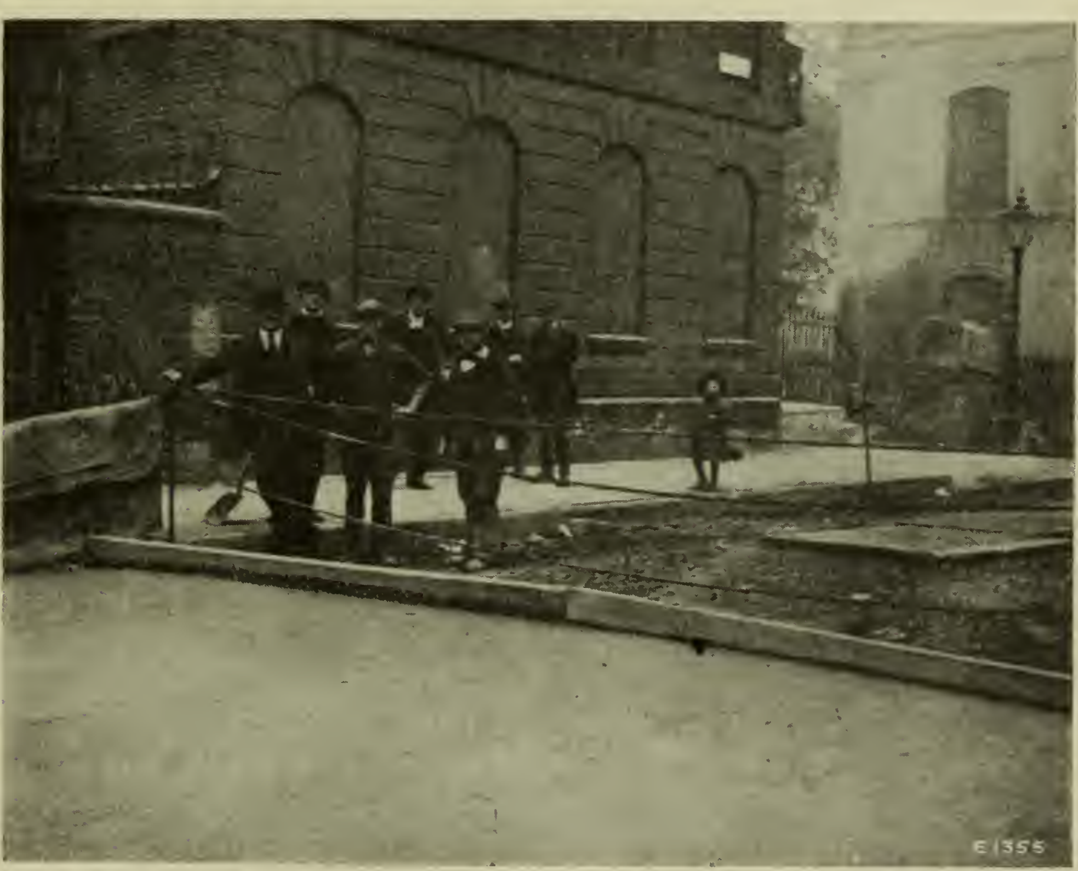


Fig. 1. Concrete Road in Brockham Street, Southwark. The end of a day's work. Note the planks by means of which the vertical edge is formed.

The joints are first tarred, and after an interval of some weeks the whole road is coated with tar and sand. This gives a surface which is not too smooth and which affords a good grip for horses and wheels.

The traffic is kept off the roads for about three weeks.

The roads in question are of varying character. While not themselves main roads, several of them link up one main road with another, and all, therefore, carry a fair traffic, and the traffic on some of them may be described as heavy.

The Council has purchased a washer and grader, which operates near the site of the work, and an examination of the smaller aggregate after being washed shows it to be excellent material for a wearing course, consisting largely, as it does, of granite, clean and well graded. The economy effected by the use of the material from the original road, which was formerly sent to the tip to be got rid of, is evident.

The average cost of the roads so far laid in concrete is 12s. 6d. per super yd., which, having regard to the low maintenance cost, compares very favourably with macadam, the maintenance cost of which is very high in Southwark. The borough engineer is of the opinion that macadam is quite unsuitable for town roads and streets, and has the utmost confidence in concrete, which he believes will in all cases ultimately be cheaper than any other form of road construction.

All the men employed are keenly interested in their work, and it is noteworthy that the majority are recently demobilised men who have never previously done any work of this kind, and have been trained by the engineer's staff.

Fig. 2 shows one of the roads open to traffic.

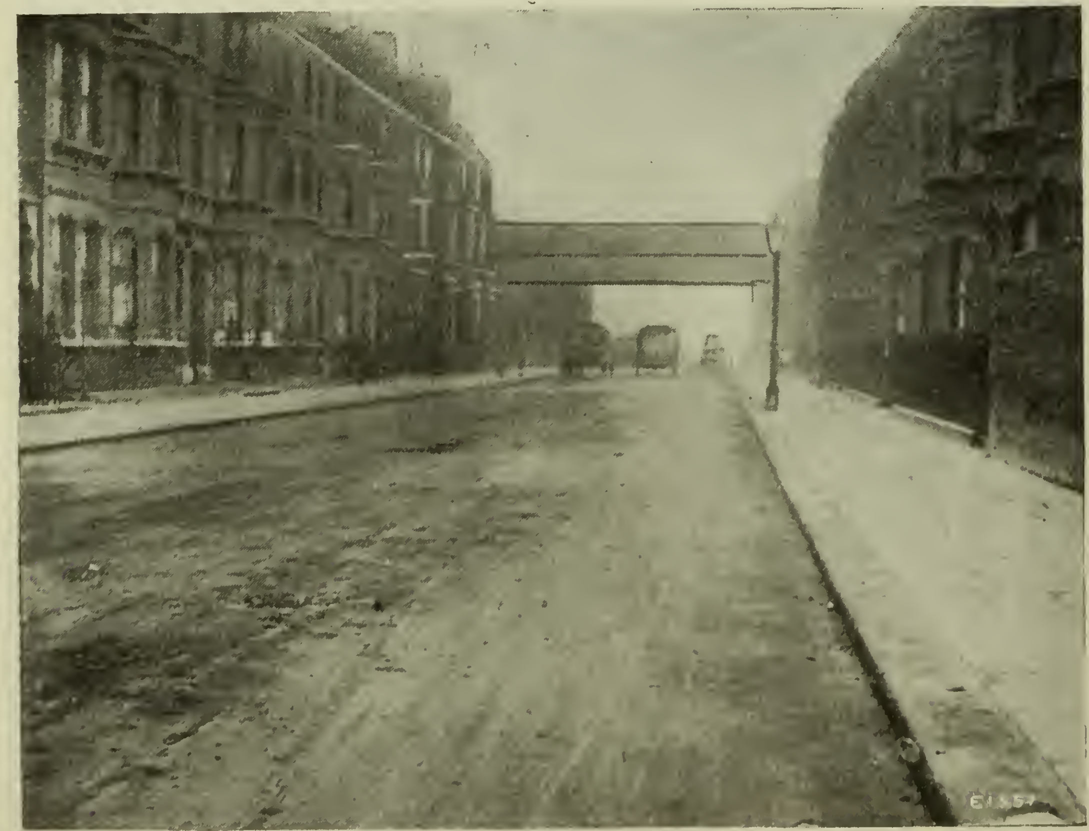


Fig. 2. Concrete Road in Steedman Street, Southwark. This thoroughfare has been open to traffic for three months. Although the photograph was taken soon after a heavy shower of rain it will be noticed that, with the exception of a few damp patches, the road is already dry.

DEPTFORD.

By the courtesy of Mr. F. Wilkinson, A.M.Inst.C.E., A.M.I.Mech.E., the borough engineer, an opportunity was recently afforded of inspecting a concrete road which has been laid in New King Street. Certain features render this construction unique, and it is probably the only one of its kind in the kingdom, if not in the world.

The length of this street is about 350 yds., and the average width 16 ft . The traffic passing through this thoroughfare, though it is not a main road, is said to be amongst the heaviest in London, since the street leads to the entrance of the Supply Reserve Department, and owing to the narrowness of the road, which does not admit of any spreading out of the traffic, the whole weight and impact will be concentrated within narrow limits. This will constitute a very severe test.

The two special features of this construction are :—

1. Double reinforcement, one layer being placed near the top, and the other near the bottom.

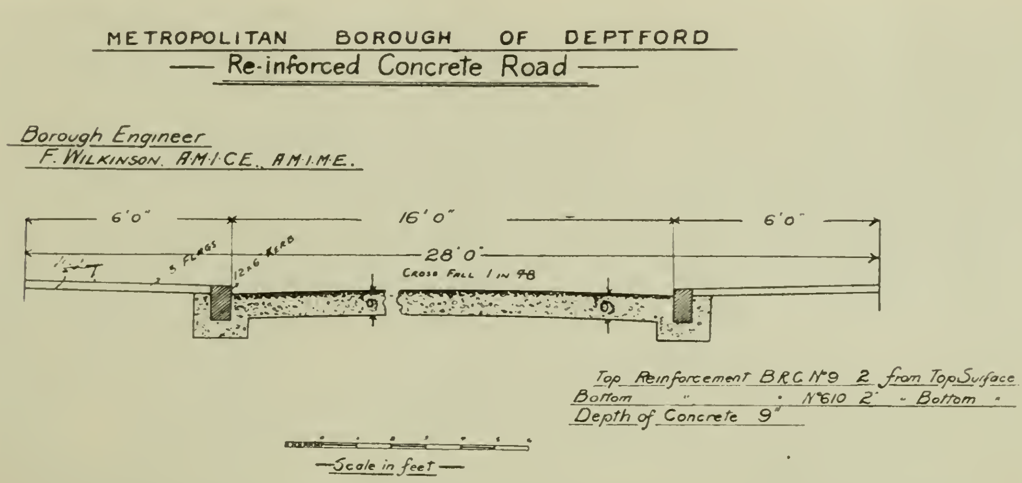

METROPOLITAN BOROUGH OF DEPTFORD
Re-inforced Concrete Road
Borough Engineer
F. WILKINSON. A.M.I.C.E., A.M.I.M.E.
6'0"
16'0"
6'0"
28'0"
5 FLAGS
12×6 KERB
CROSS FALL 1 IN 48
Top Reinforcement B.R.C. No 9 2 from Top Surface
Bottom " " No 610 2" " Bottom "
Depth of Concrete 9"
Scale in feet

Fig. 3. Transverse section of the Concrete Road laid in New King Street, Deptford, showing the kerbs embedded in concrete.

2. The dipping down of both concrete and the lower reinforcement under the kerb and up on the inside as shown in *Fig.* 3 ; the kerbs are of granite.

The lower reinforcement takes the stresses due to the weight of the traffic in the usual way ; the object of the upper reinforcement is to take the stresses due to the horizontal motion of the traffic, the theory being that there is a tendency for the particles of concrete *in front* of a moving wheel to be pushed forward, with a reverse tendency in the case of the particles behind the wheel. Between those two a tensional stress is set up, and it is to take this stress, and so prevent cracks, that the upper reinforcement is intended. It is also considered that the double reinforcement renders expansion joints unnecessary ; these have, therefore, not been provided.

A great deal of thought has been devoted by Mr. Wilkinson to these special features, and they have been discussed over and over again with experts in road reinforcement and road laying..

Our readers will remember that the Port of London Authority's concrete road at the Royal Albert Dock has a double reinforcement, but this differs from that of the Deptford road in that the top and bottom layers are tied by diagonal members forming a rigid mattress. The marshy nature of the ground at the Royal Albert Dock renders double reinforcement a necessity; in Mr. Wilkinson's case it is a matter of choice, for use in any situation where heavy traffic has to be borne.

Construction.—No special foundation was prepared, as the sub-grade of the original road was found to be sufficiently firm for this purpose.

The road is constructed in two courses, a lower, 6½ in., and an upper, 2½ in. On account of the upper reinforcement it is not possible to lay the surface coat before the concrete of the lower has set; the former is, therefore, laid 24 hours after the latter, this being the earliest time at which the men can get on to the concrete to place the second or upper reinforcement in position.

The lower reinforcement (No. 9 B.R.C. mesh) is first placed in position 2 in. from the bottom. To keep it in place the mesh is stretched over a 2-in. plank, and is supported elsewhere by portions of concrete passed through the mesh. The wet mixture is then deposited to a depth of 6½ in. and left until next day. After an interval of 24 hours the top reinforcement is placed and supported in position ½ in. above the surface of the lower concrete, and the wearing coat deposited to a depth of 2½ in., ½ in. below the reinforcement and 2 in. above it. Thus the depth of the concrete for the whole is 9 in.

The surface is finished with a wooden float.

The amount of camber is 1 in 48, to obtain which a screed is used. This which is very shallow, remains in position until the concrete has set. It is then, removed, the trench extended down to the first reinforcement and filled with the same mixture as the wearing coat.

Unwashed Thames ballast graded up to 1 in. is used for the lower course in the proportion of 6 : 1, and Mount Sorrel chippings and sand 3 : 1 for the wearing coat: the former passing a ⅜-in. sieve. Mr. Wilkinson would prefer to use ¾-in. granite chippings for the lower course. Fig. 4 shows this road in course of construction.

It is not proposed to surface this road with tar, but to test it, at any rate for some months, as an unsurfaced concrete road. An experiment is, however, being made in material in the following way with a view to ascertaining which treatment produces the best results in point of wearing quality.

The length of the road has, for this experiment, been divided into four sections, in each of which a different treatment has been adopted for the wearing coat, thus:—

Section 1. Wearing coat plain 3 : 1 concrete.
Section 2. Same as section 1, but sprinkled with powdered carborundum.
Section 3. Plain 3 : 1 concrete with a different brand of cement.
Section 4. Same as No. 3, but sprinkled with carborundum.

The carborundum has been laid to prevent horses from slipping. It is, of course, applied while the concrete is wet, and is not tamped but allowed to sink in by its own weight.

After the concrete has set sufficiently hard the surface was covered with damp sand to a depth of 2 in. or 3 in., and the traffic was kept off the road for a month.

The work was carried out by the Council's own men. The mixing was done by hand, but this was only because of the difficulty in obtaining a mixing machine in time for the job.

The cost of this road was 17s. per super yd., but now that the men have experience in this form of work it is expected that the next concrete road will be laid at a cost of from 10s. to 12s. per yd.

Mr. Wilkinson is obviously a concrete enthusiast, and has advocated concrete roads for two or three years past. The exigencies of war, however, have prevented him from putting his ideas into practice earlier. He has great faith in his system, and proposes to give the road he has already laid a fair trial. The road has been open to traffic for over four months, and with the exception of two or three small surface cracks there is nothing to indicate any deterioration whatever. If, after the winter months, no deterioration has taken place, Mr. Wilkinson intends to lay several more roads on the same method.

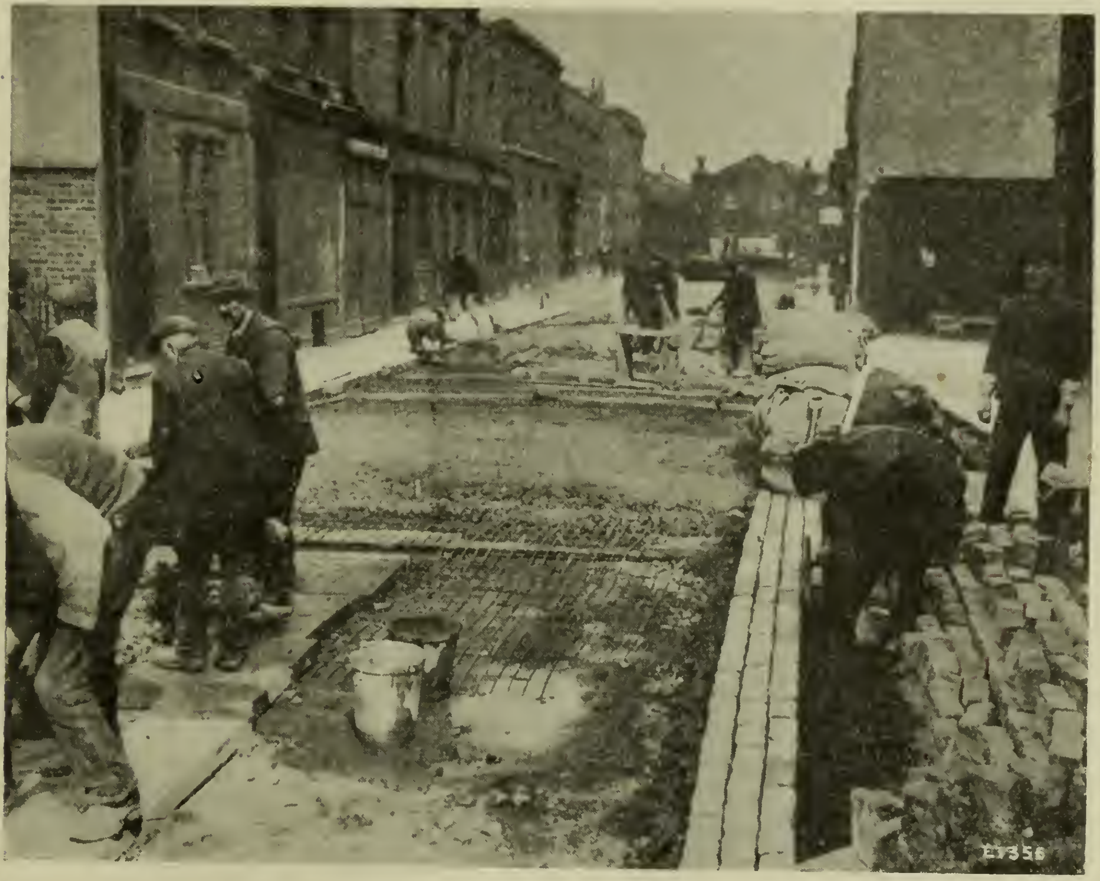
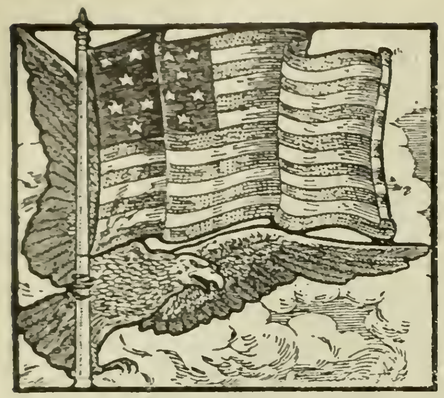


Fig. 4. Concrete Road under construction in New King Street, Deptford. The reinforcement for the lower course, stretched over a 2-inch plank to keep it in position, is seen in the foreground.



DOES RICH CONCRETE IN ROADS CRACK MORE THAN LEAN?

In order to obtain some expression of opinion on the above subject, "Engineering News-Record" recently sent out a questionnaire to a few engineers in the United States who have taken a leading part in the use of concrete for roads. The questions asked were the following, and we give below the answers received which will probably be of some interest, especially at the present time when the question of the concrete road is receiving considerable attention.—ED.

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1. Does rich concrete crack more than lean concrete? 2. If so, is this particularly the case with concrete highway pavements and foundations? 3. What reason do you assign for the greater tendency to crack in rich mixtures? 4. Would you advocate leaner concrete in roads, to overcome this tendency? 5. What do you consider to be the principal causes of (1) transverse cracks in pavements; (2) longitudinal cracks in pavements?

Volume Changes From Climatic Variation Greater in Rich Concrete.

By J. C. Pearson,

United States Bureau of Standards.

My answer to your inquiry of June 19th in regard to highway concrete is based more on general considerations than on an intimate knowledge of the requirements of road construction. Referring specifically to your five questions, I beg to submit the following replies:—

1 and 3. Rich concrete in itself has a greater tendency to crack than lean concrete, due to its greater volume change under varying conditions of moisture and temperature.

2. This is particularly the case with highway concrete, unless the design is such as to take care of the volume changes.

4. I would advocate the use of leaner concrete in roads if there were any assurance that the quality of the workmanship in mixing and placing could be controlled. For example, the use of a larger proportion of coarse aggregate in the commonly specified mixtures would undoubtedly result in better roads, provided the contractor were willing to do the necessary additional work in properly placing the leaner mixtures, and the builder were willing to pay for the additional work and the improvement in quality. As a general proposition, it would hardly be wise at the present time to recommend the use of leaner mixtures.

5. Transverse cracks are in many cases due to shrinkage; longitudinal cracks are more likely to be due to lack of uniformity in sub-base conditions.

Leaner Concrete in Roads Would Lead to Failures as Heretofore.

By William D. Uhler,

Chief Engineer, Pennsylvania State Highway Department, Harrisburg, Penn.

In my estimation there is no practical difference, as far as cracking is concerned, due to the difference in richness between 1 : 2 : 3 concrete as wearing surface and 1 : 3 : 6 concrete as base. I am conversant with the results of many laboratory tests which seem to tend toward proving that the use of rich concrete minimises the tendency toward cracking due to the absorption of water.

I would most assuredly not recommend the use of leaner concrete in concrete roads. Such cracking as has occurred on our reinforced-concrete roads is easily taken care of by the use of asphalt or tars, at a very slight expense. I feel that the use of lean concrete would but lead to such failures as were experienced in the early history of concrete pavements.

We have made a survey of some of our reinforced-concrete roads in this state, and the cause of cracking is given in the percentage table herewith :—

	Transverse, Per Cent.	Longitudinal, Per Cent.	Irregular, Per Cent.
Drainage	43	30	44
Weak subgrade	8	63	42
Road entrance, etc.	30	3	10
Trees	8	4	—
Culverts	8	—	—
Trolley crossing	3	—	4
Total	100	100	100

The Stronger the Concrete the Fewer the Cracks.

By EDWARD N. HINES,

Chairman, Board of Wayne County, Michigan, Road Commissioners,
Detroit, Mich.

The Board of County Road Commissioners of Wayne County, Michigan, has, during the past eleven years, constructed approximately 180 miles of concrete roads, which are giving excellent service at a very reasonable maintenance cost. I am impressed, first, by the fact that to me your questions imply that a crack in a concrete road necessarily constitutes a grave defect. In my opinion, this is far from being the case. When one can ride over these roads and cannot tell, with his eyes closed, of the existence of any cracks, they certainly cannot be considered as affecting seriously the service that the road renders to the public.

To answer specifically your question as to whether more cracks will occur with a rich concrete mixture than with a lean mixture : I have never seen, or, from inquiries that I have made, can I learn of, any data of a scientific character which would give a definite answer to the question. My observation leads to the conclusion that the stronger the concrete the fewer the number of cracks ; that is, a concrete of a rich mixture will develop fewer cracks than one of a leaner mixture.

The best evidence I can cite in support of this statement is gained from my knowledge of a considerable mileage of concrete roads in California. These roads were built, as I am informed, of 1 : 2½ : 5 mixture ; considerably leaner than what we have used on our Wayne County roads, 1 : 1½ : 3.

On the California roads it is to be observed that transverse cracks occur at intervals of 12 to 18 ft., while on our roads in Wayne County the interval is much greater. On a number of miles of roads in Illinois, of which I have knowledge, the interval between cracks is 30 to 40 ft. To me, a layman, it is inconceivable to suppose that a weaker concrete road surface would have fewer cracks than one which was stronger, as your questions would imply.

The above will answer your first four inquiries. As to the fifth, concerning the cause of transverse and longitudinal cracks, my observation inclines me to the opinion that transverse cracks are caused primarily by the shrinkage or contraction of the concrete, while longitudinal cracks are mainly caused by unequal movements of the subgrade, doubtless due to imperfect drainage conditions.

Laboratory Experiments Indicate Rich Concretes Crack More.

By P. St. James Wilson,

Acting Director, United States Bureau of Public Roads.

Answering your questions in the order in which they were propounded, it is our belief that there is a tendency for rich concrete to show more frequent cracking than lean concrete, and this tendency is borne out by the results of laboratory experiments. Experiments were made in this office and the results were published in our department Bulletin No. 532, entitled "Expansion and Contraction of Concrete and Concrete Roads." In this bulletin it is shown that rich mortars shrink more when dried out than lean mortars, and it is reasonable to suppose that the same tendency exists in concretes but to a less marked degree. We believe that in view of the tendency for concrete bases to remain in a rather damp condition the shrinkage effect, due to the drying out of concrete, is generally quite small, and that the difference between the shrinkage of rich and lean concrete bases must also be quite small, due to this cause. We believe that temperature effects are about equal, whether the base is rich or lean.

It is our belief that in view of the tendency of concrete pavements and foundations to retain some moisture on account of their contact with the underlying subgrade, the tendency toward cracking should be less than in the case of constructions which are subjected to a more thorough drying.

It has been shown by a number of investigators that neat Portland cement shows enormous shrinkage upon drying, and that as more sand is added the shrinkage is decreased. No attempt will be made to theorize on the reason for this action.

We believe that the use of leaner concrete on concrete bases is not likely to reduce the cracking of the concrete to any great extent. We can conceive, however, of a concrete being so lean and so porous that cracking may result from frost action. It is our belief that such action has occurred in many cement sidewalks in which an excessively lean base has been used.

Lean Concrete Pavements of No Value Whether They Crack or Not.

By A. N. Johnson,

Consulting Highway Engineer, Portland Cement Association.

Regarding the relative amount of cracking to be observed in lean and rich mixtures, I have never seen any results, compiled from any authentic source, that bear out the suggestion that a concrete pavement made of a lean mixture had fewer cracks than one of a richer mixture.

A lean concrete pavement is of no value whether it cracks or not, and it is beyond my comprehension how such a proposition could arise. The results of my own observation are exactly to the contrary—that the weaker the concrete the greater the number of cracks to be observed, other conditions being the same.

Your fifth question, as to the cause of transverse and longitudinal cracks, I believe has been fairly well discussed, transverse cracks being caused in by far a greater number of instances through contraction of the concrete slab due to both shrinkage of the concrete at the time of setting and to contraction due to drying out and the lowering of the temperature.

Longitudinal cracks are for the most part caused by movement of the subgrade which is not uniform throughout its extent. In general, the fact that a crack does appear in a concrete road by no means indicates that the road renders less effective service for the passage of traffic, and practical experience shows that the average crack which occurs occasionally is no serious defect to the road surface.

Within Limits of Allowable Proportions, No Difference in Cracking.

By Clifford Older,

Chief State Highway Engineer, Illinois.

Replying to your recent letter propounding questions concerning concrete and concrete pavements, I wish to offer the following replies :—

1, 2 and 3. Within the limits covered by the proportions usually used in mixing concrete, I do not believe that there is any appreciable variation in the tendency to crack.

4. I would not advocate using leaner concrete in roads with the idea of overcoming a tendency to crack, since I am not convinced that this procedure would accomplish the end desired. I personally feel that the proportions of the concrete should be determined to give the required strength to the pavement.

5. (*a*) There has been a great deal of conjecture as to the causes of cracks in pavements, and I hardly feel that anyone can give an absolutely correct answer to such a question. In my opinion, transverse cracks in pavements are formed due to the alternate expansion and contraction under temperature change. Also, the fact that a pavement occupies a greater volume at the time of its construction than it occupies after the concrete has attained its full set may have some tendency to produce the transverse cracks. I feel, however, that transverse cracks in pavements are of minor importance. We have experienced no difficulty in maintaining such cracks with bituminous material so that they are absolutely protected at a very nominal expense ; (*b*) the cause of longitudinal cracks is also more or less problematical. However, I have observed that pavements 10 ft. in width or under have practically no tendency to crack longitudinally, whereas pavements having a width of 16 ft. and greater almost invariably develop longitudinal cracks. I feel that this is due largely to the difference in the saturation of the soil from the edges toward the centre of the pavement. This, combined with freezing, will naturally cause a greater displacement at the edges than at the centre, which results in a flexural stress along the centre line, producing a tendency to crack. Also, this saturated condition without the action of freezing may cause the centre of the subgrade to be more firm than the outside portions, which might produce flexural stress under traffic, resulting in a tendency to crack longitudinally.

I have also observed that longitudinal cracks almost invariably start at a joint or at a transverse crack. I have wondered if this is not due to eccentric application of the compressive stresses set up by expansion. It is well known that an eccentric application of a compressive stress on any concrete specimen tends to cause irregular stresses. In placing joints in a concrete pavement, it would seem almost impossible to get a uniform bearing of the ends of the slab against each other. Compressive stresses might then be applied very irregularly, resulting in a tendency to split the pavement longitudinally. The same theory might apply in the case of the transverse cracks tending to form longitudinal cracks.

This department has adopted the practice of building concrete roads and also brick roads without transverse joints, and, so far as we have been able to observe, there is less tendency to crack longitudinally in the case of the pavements built without transverse joints than with the pavements built with transverse joints.

No Reliable Evidence To Support Rich-Mix Cracking Theory.

By Duff A. Abrams,

Structural Materials Research Laboratory, Lewis Institute, Chicago.

I know of no reliable evidence which indicates that concrete pavements of lean mixtures crack less readily or frequently than rich concrete, particularly if the terms "lean" and "rich" are applied within the practicable range of concrete mixtures.

Past experience in several communities has shown that lean concrete mixtures do not give satisfactory results in concrete pavements. Entirely aside from the consideration of cracks, lean mixtures will not stand up under the extreme conditions of weather and traffic to which a modern road is subjected.

The principal cause of transverse cracks in pavements is the expansion and contraction due to variations in temperature and moisture. The earlier concrete-road builders attempted to counteract the opening of cracks by placing joints at intervals of 25 to 40 ft. However, experience has shown that these joints are unnecessary and that it is difficult to get the pavement at the sides of the joints at the same grade. Considerable expense is saved and better riding surfaces are, consequently, secured by reducing the joints to a minimum. The most modern practice is to place joints only at the end of each day's work. Ordinarily, this would mean one joint at each 200 to 500 ft. If transverse cracks open at other points they can be easily maintained by use of tar or some other bituminous filler. Such cracks are in no way detrimental to the structural efficiency or usefulness of the pavement.

Longitudinal cracks are generally due to inequality in the subgrade which results in non-uniform settlement of the slab. They are sometimes produced by frost action or in the unequal loading of the pavement. In the practice of constructing wide concrete roads over old macadam bases of narrow width, the unequal settlement of the paving slab, due to the newly formed subgrade, causes longitudinal cracks. Old macadam roads should be thoroughly broken up and re-rolled before a concrete pavement is constructed. Experience has shown that reinforcement has little or no effect in preventing cracks.

Rich Concretes Have Greater Tendency To Crack.

By A. H. Hinkle,

Deputy State Highway Commissioner, Bureau of Maintenance and Repair, Columbus, Ohio.

Your questions are answered in the order in which they are given in your letter :—

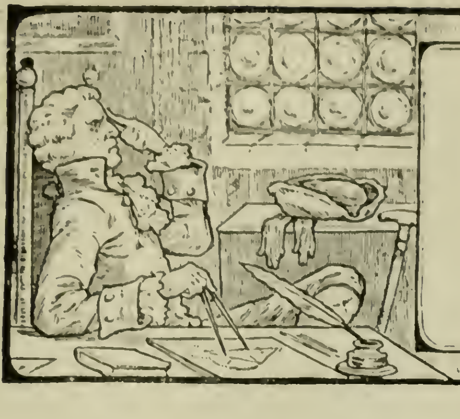
1. I have also thought that the rich concrete did crack more than the lean, although I have not made sufficient tests to offer much proof of same.

2. This would be more apt to occur in thin slabs of concrete, such as a pavement foundation.

3. I think perhaps the cracking may be less in the leaner concrete due to it being less dense, which may possibly make it more elastic.

4. I would desire to make further investigations before recommending a leaner mix.

5. (*a*) The principal cause of transverse cracks is the contraction of the pavement ; (*b*) the principal cause of longitudinal cracks is lack of stability of subsoil or too light a slab for the load which the pavement carries.



REINFORCED CONCRETE BEAM TABLE.

By ALBERT LAKEMAN, M.S.A.

The use of tables for reinforced concrete design is at present very limited, and the following should be of interest to designers generally.—ED.

MOST readers are familiar with the tables giving the properties and safe loads for varying spans of the ordinary standard rolled steel joists, and they would feel at some loss if these tables were not available when a simple beam was required and lengthy calculations were necessary; but no such tables are in existence for reinforced concrete work, and the writer feels that a great want will be filled when some suitable and reliable tables can be obtained by the designer for use in all ordinary cases. The conditions for reinforced concrete cannot obviously be quite so simple as exists in the case of steelwork, because in the latter there is a limited number of definite sections, which are rolled, and the properties of these can be determined, and an intelligent application only is then required. With reinforced concrete there are practically no limitations, and the size of the concrete and area of steel, and the relative proportions, may be varied to such an extent as to make it impossible to cover all possible sections in table form. But it is some help if a table is at hand which will give the properties and safe loads for ordinary sections which have been designed in accordance with recognised economical principles. Such a table will undoubtedly prove invaluable when approximate and sketch designs are being prepared, and it is necessary to arrive at some idea of the size and value of the concrete construction. The accompanying table deals with single reinforced beams only, and it is the intention of the writer to deal with slabs, tee-beams, double reinforced beams and columns in a similar manner at some future date, especially as the use of ordinary rectangular beams is decidedly limited; but this class forms the most simple type, and is given first for this reason.

In making the calculations, the breadth has been made equal to ·6 *d*, as this is the best ratio; and the steel has been taken at ·00675 *bd*, as this is the economical ratio. The loads given are the safe superimposed loads in pounds (to the nearest pound), and as the moment of resistance and weight per foot run are given, the safe load for any different form of loading can be easily determined. The theoretical area of steel is given, and also the nearest practical size and number of rods required. It will be found that the latter is generally a little in excess, but this can be varied by the designer as desired, providing that the amount provided is equal to the calculated area given in the table. Different

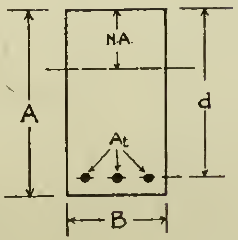
UNIFORMLY DISTRIBUTED
SAFE LOAD IN POUNDS

SINGLE REINFORCED CONCRETE BEAMS

ENDS SUPPORTED

SIZE			A_t	N.A.	M.R.	WGT		SPANS IN FEET																				STEEL RODS		
A	B	d	Sq.Ins	INS.	INCH LBS	LBS. PER FT	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Nº	DIA.	AREA
4	1¾	2·75	·03	0·99	1161	7·29	164																					1	¼	·049
5	2¼	3·75	·057	1·35	3009	11·71	454	342	264																			1	⅜	·1104
6	3	4·75	·091	1·71	6086	18·74	939	717	563	448	357																	1	⅜	·1104
7	3½	5·75	·134	2·07	10848	25·5	1706	1319	1052	854	700	574																1	½	·1963
8	4	6·75	·184	2·43	17487	33·33	2781	2165	1743	1432	1190	995	832	693														1	½	·1963
9	4¾	7·75	·243	2·79	26516	44·53	4241	3312	2679	2213	1853	1563	1322	1117	938	781												1	⅝	·3068
10	5¼	8·75	·310	3·15	38192	54·68	6146	4818	3915	3254	2745	2336	1999	1713	1465	1247	1053											2	½	·392
11	6	9·75	·385	3·51	52852	68·74	8533	6703	5460	4552	3854	3296	2836	2447	2111	1816	1554	1317	1102									2	½	·392
12	6½	10·75	·468	3·87	70836	81·24	11481	9038	7383	6177	5253	4516	3910	3399	2960	2576	2235	1929	1651	1396	1161							2	⅝	·613
13	7	11·75	·559	4·23	92480	94·78	15034	11856	9706	8144	6948	5997	5217	4562	4000	3510	3076	·2688	2336	2015	1719	1444						2	⅝	·613
14	7¾	12·75	·658	4·59	118124	113	19235	15184	12446	10459	8939	7733	6745	5916	5206	4588	4043	3555	3113	2711	2341	1997	1677	1377				2	¾	·883
15	8	13·5	·738	4·86	140279	125	22879	18078	14836	12485	10690	9266	8102	7126	6293	5568	4930	4359	3845	3376	2945	2547	2176	1828	1500	1191		3	⅝	·92
16	8¾	14·5	·851	5·22	173740	145·8	28373	22436	18429	15526	13312	11557	10124	8925	7902	7014	6232	5534	4906	4334	3810	3326	2875	2453	2057	1682	1327	3	⅝	·92
17	9½	15·5	·973	5·58	212347	168·2		27472	22585	19046	16350	14215	12474	11019	9778	8703	7757	6914	6156	5468	4837	4255	3714	3209	2734	2286	1861	4	⅝	1·22
18	10	16·5	1·10	5·94	255552	187·4		33136	27270	23028	19796	17243	15162	13426	11948	10669	9545	8546	7649	6835	6091	5406	4770	4177	3621	3097	2601	4	⅝	1·22
19	10½	17·5	1·24	6·30	305536	207·8		39699	32701	27644	23799	20762	18291	16231	14480	12967	11640	10462	9405	8449	7575	6772	6028	5335	4687	4076	3500	3	¾	1·32
20	11	18·5	1·38	6·66	359462	229·1			38565	32630	28122	24565	21673	19265	17221	15455	13909	12539	11312	10201	9189	8259	7400	6600	5852	5149	4486	5	⅝	1·534
21	11¾	19·5	1·54	7·02	422822	257			45438	38469	33179	29007	25618	22798	20406	18342	16536	14937	13505	12212	11034	9952	8954	8026	7158	6344	5577	4	¾	1·76
22	12½	20·5	1·70	7·38	490688	286·4			52802	44727	38599	33769	29848	26588	23823	21440	19356	17512	15863	14373	13018	11775	10628	9563	8568	7635	6756	4	¾	1·76
23	13	21·5	1·87	7·74	566086	311·4				51733	44682	39129	34625	30882	27712	24981	22596	20488	18604	16905	15361	13946	12641	11431	10303	9246	8251	5	¾	2·208
24	13½	22·5	2·05	8·10	649440	337·4				59489	51420	45070	39922	35648	32031	28918	26202	23803	21661	19732	17980	16376	14900	13531	12257	11064	9942	5	¾	2·208

Ratio of d to span to be not less than 1/20th
Minimum span in feet equals 1/3rd. depth of beam in inches
Weight of Concrete taken at 150 lbs. per foot cube
Safe stress on Concrete taken at 600 lbs. per sq. in.
" " " Steel " " 16000 " " " "
A - overall depth in inches d - effective depth in inches
B - " breadth " " N.A. - depth of neutral axis in inches



sized rods can, of course, be used, as, for example, in the case of a beam 23 inches deep, the practical reinforcement is given as five ¾ in. diameter rods, having a total sectional area of 2·2085 sq. ins., whereas if three ¾ in. diameter rods and two ⅝ in. diameter rods are used, the area would be 1·3251 + ·6136 = 1·9387 sq. in., which is sufficient, and the saving is comparatively large.

Where economy is a primary consideration, the absolute minimum can be worked out, and this process will only take a few moments. Again, the sectional area of steel required is that for the centre of the span where the bending moment is at a maximum, and the whole of the rods need not be carried through the full length of the beam ; but the points at which rods are to be dropped or cranked must necessarily be the subject of a drawing when a beam is detailed. No vertical shear members are theoretically required, as the concrete will in all cases be enough to resist this stress, but for practical purposes some stirrups should be provided, To comply with the requirements of the London County Council, for work in London, these stirrups must be placed at distances apart not exceeding the effective depth of the beam. The small beams which are given may be useful for lintels or similar purposes, as a beam 4 ins. deep, for example, would not be used for floor construction because a plain slab would answer the purpose in such a case.

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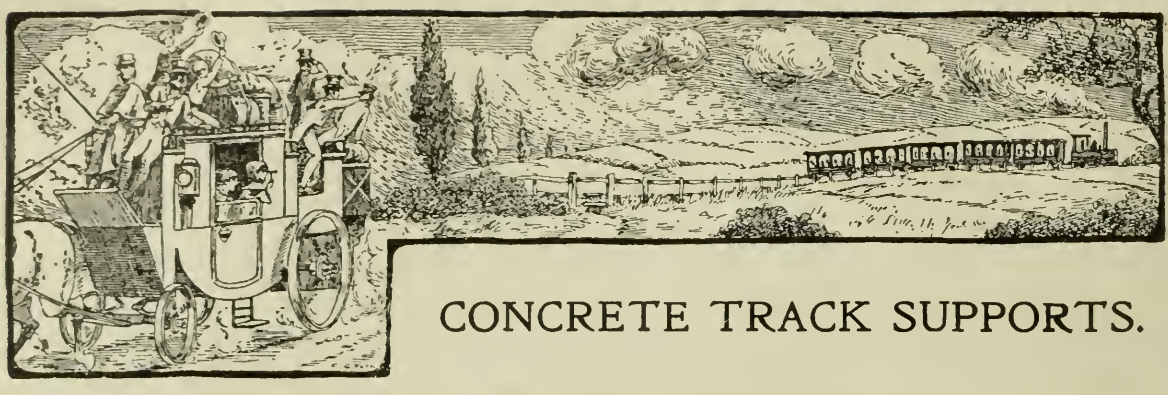
MEMORANDA.

Cement Joints for Cast Iron Water Mains.—We have made frequent references to the use of cement joints for water mains, and we give below some particulars of such joints at a shipbuilding plant :—

Cement joints for 6-in. and 8-in. cast-iron pipe are being used on automatic sprinkler and salt-water fire protection systems at San Pedro, Calif., by the Los Angeles Shipbuilding & Dry Dock Company. A total of 3,975 ft. of 6-in. and 6,250 ft. of 8-in. has so far been laid. Only three defective joints had to be cut out and remade. An average of 5 per cent. had a slight sweat which disappeared in a few hours.

Riverside Portland cement is used with soft yarn entirely free from grease. The joints are spaced by using just enough yarn with which to keep the cement from going inside—the less cement the better. The yarn is soaked in liquid cement before using. Neat cement only is used. It should be rather dry, and the ideal condition will be found to be when it is moistened just sufficiently to ball when pressed with the hand. This is tamped in solidly against the packing yarn by hand with a large caulking iron. Caulking with cement is continued until the bell is entirely filled and the caulking iron will hardly make an impression on the cement and the bell rings. The joint is then wiped with a cement paste to a 45-deg. angle.

In making cement joints the pipe must be on a solid bed. If the trench has been made a trifle too deep, the pipe joints are blocked up on wood, so that they have a firm foundation. The trench is water-filled, so that when the blocks rot, the dirt will become solid, and the pipe well bedded. Tests are not made until 48 hours after the last joint has been caulked. The trench is filled between joints. Each joint after being made is kept covered with pieces of wet sacks during the 48-hour period, after which a pressure of 180 lb. per sq. in. is kept on the line for two hours. About 600 ft. of pipe was tested at a time.



CONCRETE TRACK SUPPORTS.

By A. C. IRWIN, Portland Cement Association.

The following is a report presented at the last Convention of the American Concrete Institute, and deals with some interesting problems bearing on the eccnomy in maintenance costs on American railways.—ED.

Practically all expenditures that have been devoted to the improvement of railroad facilities and equipment may be traced to the necessity of obtaining greater traffic concentration. The tractive power and speed of locomotives has been enormously increased in order that longer and heavier trains may be used. The carrying capacity of cars has been increased many fold, so that a greater weight may be carried in a smaller length of train. Bridges have been replaced with stronger ones and terminal facilities have been enlarged and made more efficient through the introduction of special appliances for handling freight. Automatic block signals have been introduced, so that trains may follow each other in quick succession. Many millions of dollars have been spent in reducing gradients so that longer and heavier trains may be employed, and so that the time required to pass between given points may be reduced. All of these improvements are centred around the one proposition of gaining the greatest possible concentration of use of track. Double track operation is a corollary to this proposition, because with such operation trains can be run much more often in each direction than under single track operation.

It is an almost unbelievable fact that the most fundamental factor concerned with greatly increased density of traffic, namely, the track itself, has been neglected, in so far as engineering design is concerned. The obvious solution of any given problem is too often followed. Therefore, if heavier trains are desired, more powerful motive power must be furnished and thus stronger bridges, etc. If trains are to be run closer together some system must be devised for protecting them which would not require an operator every $\frac{3}{4}$ mile or so, hence the block signal system. All these are obvious ways of obtaining greater use of track and are, of course, necessary to the accomplishment of the desired end. However, they have been carried out apparently with forgetfulness of the effect of heavy locomotives and cars on the track itself, and the maintenance thereof, and without any serious attempt to evolve a track construction adequate to the new demands upon it. O. E. Selby writes in a bulletin of American Railway Engineering and Maintenance of Way Association: "Railroad track has grown in strength as heavier loads have made increased strength necessary, but such growth has been entirely along empirical lines and not one single detail of track superstructure bears marks of engineering design." It is true that heavier rails have been used, but the extra strength afforded by these rails has not at all been in proportion to the increased loads which they are called upon to carry. A greater number of ties have been used per rail; that is, ties have been spaced closer together, thus affording some increase in bearing area on the ballast, but this increase has been wholly out of proportion to the increase in wheel loads. A greater thickness of ballast has been used, but since there is nothing to retain this ballast in any given position it spreads out and is driven into the subgrade.

It is a well-known fact that any machine, structure, or living thing, wears out with astonishing rapidity after a certain point of strain is reached and passed. The limit of the supporting power of the ordinary track construction at which the track could be economically maintained has long since been passed and the result is that we are now endeavouring to keep in first-class condition a structure which is being continually stressed beyond the point where such stress can often be repeated. This accounts in a large measure for the fact that increased cost in maintenance of track has largely nullified the advantage aimed at through the expenditure of millions of dollars on motive power, grade reduction, block signalling, and improved terminal facilities. Moreover this cost is unnecessarily heavy. Even in 1896, when ties were plentiful and fairly cheap one-sixth of the entire cost of operating the railways in the United States was expended on care and maintenance of the track alone. This ratio has now increased to nearly 25 per cent. of total operating expenses, and is becoming more difficult owing to the increase in cost and greater scarcity of labour and material.

FUNDAMENTALS OF TRACK DESIGN.

A question of reducing maintenance costs below what they are at the present day, can only be solved by a new and better design of the original track. It is apparent that the fundamental difficulties in obtaining a satisfactory track condition with the present type is really the fault of the type itself. It is not practicable to obtain a structure that will be free from large deflections under heavy loads or which will maintain its position as to grade and line for any length of time without constant attention, with individual supports having no connection with each other longitudinally, excepting through the medium of the rails, and resting on material possessing little or no cohesion and, therefore, little ability to distribute loads uniformly to the subgrade. The type of track foundation needed is one that has sufficient longitudinal and transverse strength to distribute the loads to a well compacted subgrade in such a way as not to exceed the bearing power of that subgrade, and surmounted by rails that are held firmly in place along which the wheels may roll with least possible resistance, and which may be easily adjusted or replaced. With this type of construction it would only be necessary to provide a smooth, hard wear-resistive contact rail which would be supported throughout all its length. Present track construction is a mixture of these ideas. It embodies the principles that the rail is a contact or wearing surface, and a girder acting to distribute the load to the ties. The ties, however, do not afford a construction having sufficient longitudinal and transverse strength as they are given such a wide spacing that each acts independent of the other, except as affected by the strength of the rail. Moreover, the size, strength, and material of the ties are such that they may easily be deflected.

TYPES OF CONSTRUCTION PROPOSED.

We will only be able to achieve the ideal track construction, when we have approached as closely as practicable the fundamental conditions to be observed in its design. Such types have been occasionally proposed. Three general classes embodying these principles are as follows :—

First.—Longitudinal stringers under the rails.

Second.—A slab having some longitudinal and transverse strength laid directly on the subgrade and carrying ballast and ties.

Third.—A slab having longitudinal and transverse strength laid directly on the subgrade and carrying the rails either directly on the slab or with blocks or longitudinal stringers between the rails and slab. In this type no ballast is used.

In the early days of steam railways the first type of construction was immediately adopted and used. The old strap iron track really represented the idea of a longitudinal support for the rail.

The longitudinal wooden stringer to which the strap was connected was used to carry the load, while the strap itself merely formed the hard, smooth surface on which the wheels should run. This type of construction failed because of the use of improper materials and the lack of clearly worked out details.

All three types of construction have, however, been both utilised and developed in the investigations for determining an efficient track support of concrete.

DEVELOPMENT OF THE CONCRETE TRACK.

In January, 1899, the *Engineering News* published an article by J. W. Schaub entitled, " A Design for a Permanent Track for Steam Railways " and in this number a staff article also appeared on the subject. In the design proposed in the staff article, *Fig.* 1, the rails were laid directly on the concrete and held to gauge by 1-in. rods, 16-in centres, embedded in the portion of the concrete between the rails.

It will be noted that this design follows rather closely the original idea of having a separate longitudinal stringer under each rail to furnish the required strength. The difficulty, however, of this design lies in the fact that the two stringers are not rigidly connected transversely so that they would act together, and the load therefore is not distributed over the full width of the subgrade. An advantage claimed by this type, however, is that by carrying the longitudinal girder below the frost line all track heaving would probably be prevented.

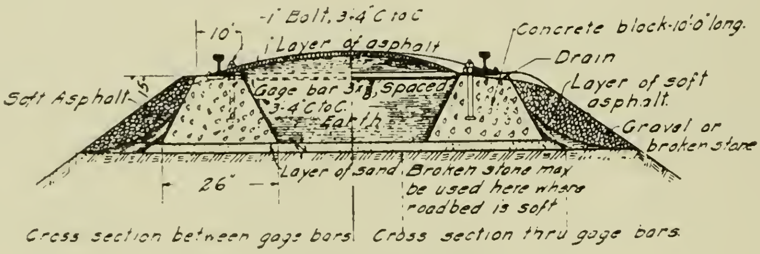

-1" Bolt, 3-4" C to C
10"
Layer of asphalt
Concrete block-10'0" long.
Drain
Layer of soft asphalt.
Soft Asphalt
15
Gage bar 3x⅝, Spaced 3-4" C to C.
Earth
Gravel or broken stone
Layer of sand
26"
Broken stone may be used here where roadbed is soft
Cross section between gage bars
Cross section thru gage bars

Fig. 1. Proposed Concrete Track in 1899.

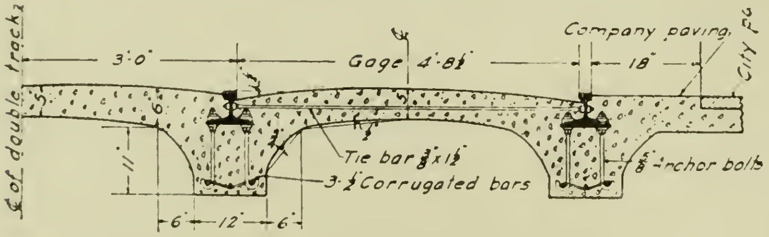


Fig. 2. Concrete Street Railway Track in Anderson, N.C.

Fig. 2 presents a type of track construction designed by E. R. Norton, jun., and used for street car tracks in Anderson and Greenville, S.C. This is in reality the longitudinal girder principle. The rails are embedded in the concrete and rest on a continuous plate. Rail clips, tie bars and hook bolt anchors are used to obtain more perfect results. After 4 years service, this track has been found satisfactory in every particular, vibration has not caused deterioration of the concrete, and even the paving between the tracks is in good condition. To adapt this design to steam railroad requirements it would only be necessary to deepen the girders and widen them out at the base for additional bearing area and to change the paving in between tracks to diaphragms at intervals below the base of rails.

SLAB SUPPORTS.

An example of Class 2, involving a concrete slab carrying ballast in which ordinary track ties are embedded is shown in *Fig.* 3. This construction was placed under 49 crossings, switches and slips on the Long Island Railroad, at Jamaica, N.Y. The

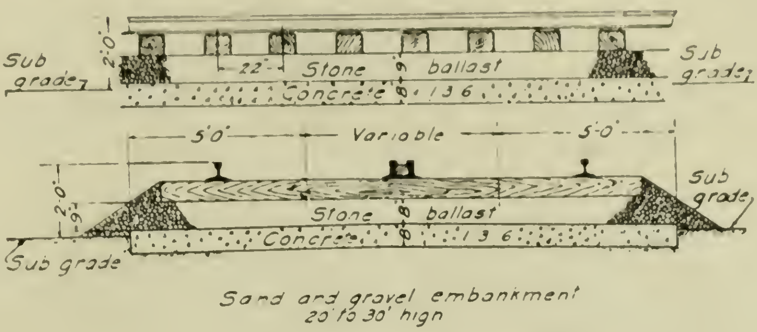


Fig. 3. Concrete Track Construction on Long Island R.R., Jamaica, N.Y.

work was put in during the winter of 1912-13 on embankments composed of sand averaging 20 ft. in height. Portions of the slabs were placed without allowing time for the embankment to settle and the traffic over these slabs has been extremely heavy from the day it was put in, running as high as 1,300 train movements per day. After 3½ years, J. A. McCrea, General Manager of the Long Island Railroad, reported that there had been practically no maintenance on the track. He further goes on to say that the great advantage of the slab is that the bearing surface on the natural ground is increased about three times what it would be with the usual method of track laying, without taking into consideration its continuity. The examination of these experimental slabs showed that there were no cracks, at least in the vicinity of the points studied. It will be noted that these slabs are not reinforced and that they are only 8 in. thick. Moreover, they have been subjected to the pounding that occurs at crossing and frogs. There can, therefore, be no question of its practicability under main line track, but where so used it would seem appropriate to construct curbs at the ends of the slabs to hold the ballast from spreading and to reinforce the slabs.

It has become very common practice to use reinforced concrete slab to form the decks of deck girder railroad bridges. These slabs are usually about 1 ft. thick, 5 ft. long, and span the distance between girders. The ballast is retained by curbs at the ends of the slabs. The testimony of railroad officials in regard to this construction is that when the ties are once embedded they stay in place and that maintenance is very greatly reduced.

The design for a concrete railroad track proposed by J. W. Schaub in 1899, is shown in *Fig.* 4. It was proposed to lay 100 lb. rails directly on the concrete, but

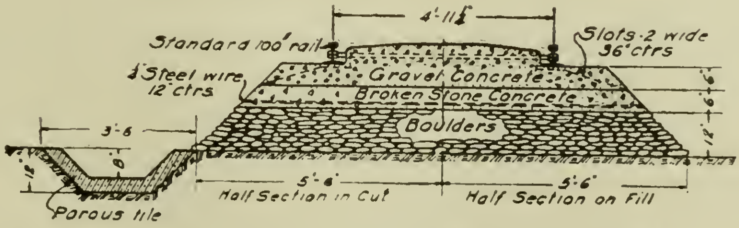


Fig. 4. Slab Type of Concrete Roadway designed in 1899.

by specifying such a heavy rail section full advantage was not taken of the continuous support afforded by the concrete thus relieving the rail of practically all bending stresses. It is also clear that the 12 in. boulders called for are entirely unnecessary.

In 1905 Mr. Schaub proposed a modification of his previous design, *Fig.* 5. In this type, a longitudinal wood stringer between the rail and the concrete is provided. This is evidently a concession to the rather prevalent notion that some elastic medium must exist between a track rail and a solid base. It also affords an opportunity to use the ordinary type of rail fastening and to replace or adjust the rails with facility. The 18 in. of rubble concrete shown is also unnecessary. All stress requirements will be provided by making the slab 12 in. thick, and placing it directly on a well compacted subgrade.

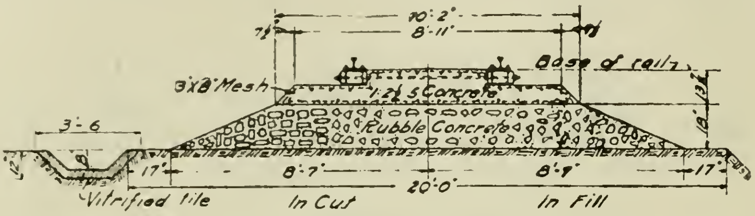


Fig. 5. Modification of No. 4.

A track used in a tunnel, and carried on reinforced concrete slabs, is shown in *Fig.* 6. This was utilised in the new Bergen Hill tunnel completed in 1909. It was designed by Lincoln Bush, then Chief Engineer of the railroad. In October, 1916, Mr. Bush said as follows in regard to this construction :—

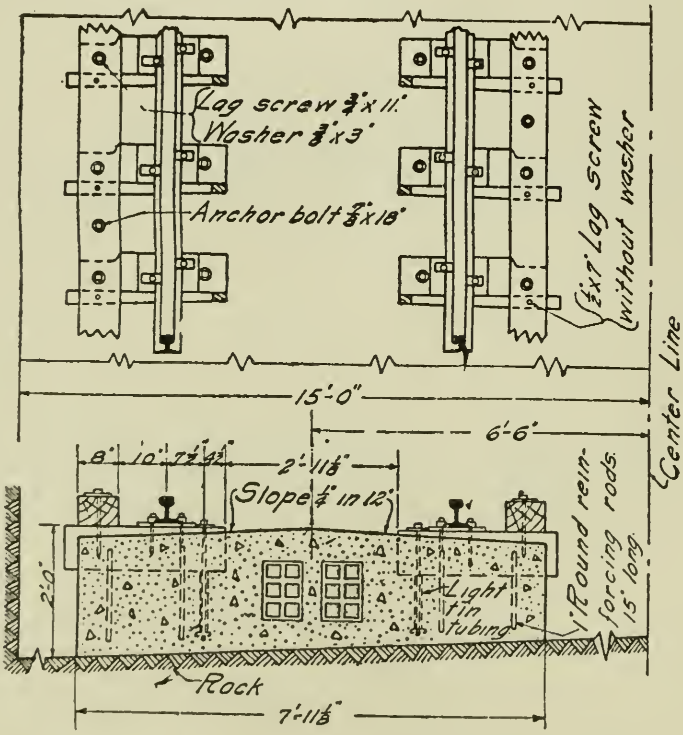


Fig. 6. Concrete Slab Road-bed in Bergen Hill Tunnel, 1909.

"The track was completed and turned over for service in February, 1909. The roadbed in the tunnel has stood up exceedingly well and none of the creosoted tie blocks have been renewed so far as I have learned on recent inquiry.

"My idea in getting out this design was that if railroad track could be made perfectly rigid and unyielding there would be no pounding or unusual stress in rail. Although the roadbed has been under the heaviest kind of traffic since erection, it has demonstrated fully that if track is made perfectly rigid, it will stand up against the heaviest kind of traffic."

The tie blocks are notched at the outer end to form a shoulder and are in place when the concrete is poured. A wedge is driven in between the concrete and the opposite side of the block, preventing the block from being disengaged from the shoulder under traffic. The blocks are replaced by removing the wedge, pushing the block longitudinal of the track so as to disengage the shoulder, and slipping it from under the rail. This work can be done by one man.

Fig. 7 shows the concrete track construction in use in the Pennsylvania Railroad Terminal Station, New York. A single track length of 14,600 ft. of this type was laid adjacent to platforms. In general the concrete was laid on the rock of the subgrade but where the subgrade consisted of loose rock backfilling the concrete slab was reinforced. A length of 720 ft. of similar construction is in use in two of the East River Tunnels immediately east of the Long Island shafts. These sections of track are subjected to high speed traffic.

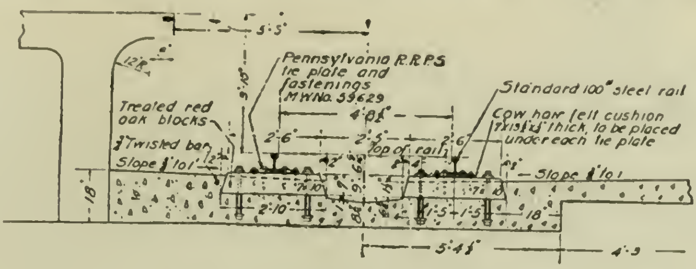


Fig. 7. Concrete Track Construction, Pennsylvania Railroad, Terminal Station, New York City.

(*To be concluded.*)

MEMORANDUM

An American Steam Shovel for Use in Construction of Concrete Roads.—In view of the interest which is at present being shown in the construction of roads in concrete, attention may be drawn to the fact that special steam shovels which are so designed as to work economically on a shallow cut such as is usually necessary in the construction of roads are already at work in this country.

This steam shovel is designed in such a manner that the bucket in taking a stroke travels horizontally forward in a straight line for a distance of 8 ft. 6 in. before this motion becomes radial ; by this means the bucket can fill itself to its full capacity on a shallow cut.

The machine runs on broad road wheels, and in ordinary ground requires no further support, it travels forward by its own mechanism, and leaves a properly graded and finished surface ready for the reception of the concrete or other material for the road formation.

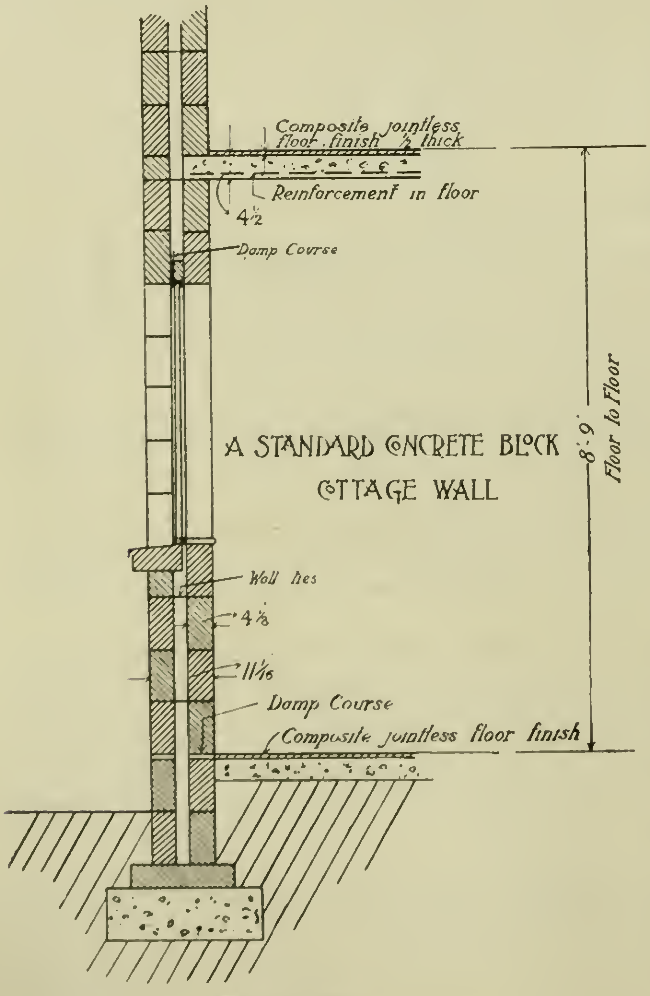
This shovel can also be used for ordinary work, and it is calculated that it will effect a considerable saving in the digging or filling of any kind of material met with in the construction of railways, docks, and public works of all kinds.

In view of the large number of roads to be constructed in this country, those of our readers concerned in this particular work will no doubt be interested in the appliance we have briefly described above, and which, we understand, will be on view at the Roads and Transport Exhibition to be held this month (November 20th to 27th), at the Royal Agricultural Hall, Islington, N.

The agents in this country for this shovel are Messrs. Wm. Muirhead, Macdonald Wilson & Co., Ltd., 41, Parliament Street, Westminster, S.W.1.

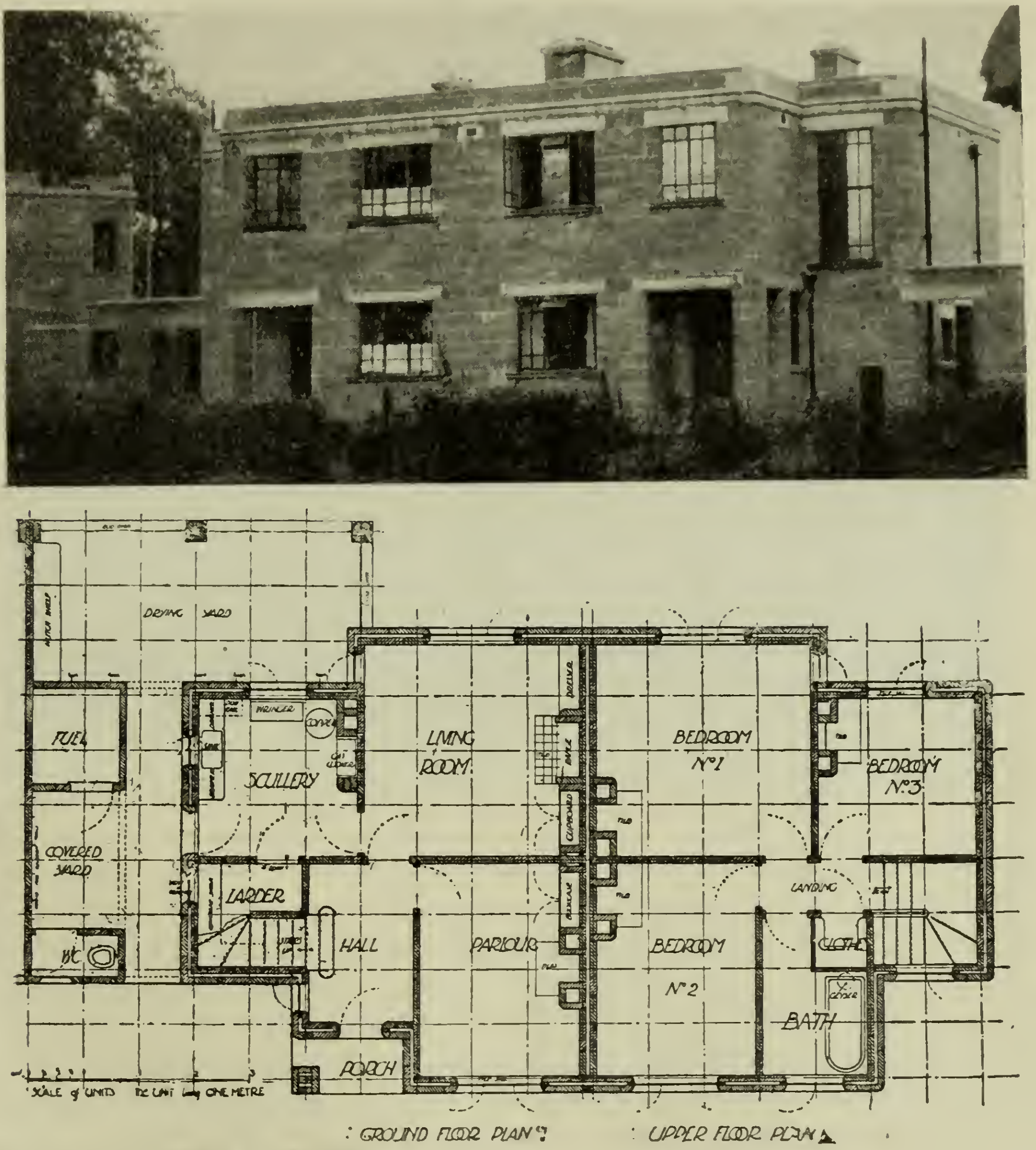
A CONCRETE HOUSING SCHEME AT BRAINTREE.

In our May issue (p. 249) we gave a description of two experimental cottages which had been erected at Braintree, and it is interesting to note that, based on this experiment, an extensive housing scheme, claimed to be the most advanced scheme in the country, and conforming with the Local Government Board Regulations, is being carried out at Braintree. The scheme, which we recently had an opportunity of inspecting, is that promoted by the Braintree Co-operative Homes, Ltd., a public utility society formed by the employees of the Crittall Manufacturing Co., Ltd., at Braintree, Essex, and the work of construction is being carried out by the Unit Construction Co., Ltd. The two houses referred to above have been in occupation for more than six months. Thirty more are in course of erection, and when completed, the estate will comprise one hundred houses, recreation rooms, bowling greens, tennis lawns and allotments. The houses are all semi-detached, and are built eight to the acre. The outside walls are unplastered, and in appearance are very similar to stone. All the cottages have flat roofs. A saving of £28 per cottage is claimed for this form of roof as compared with sloping slate roofs; but the interspersion of a few sloping roofs, or variations in the elevations, would greatly improve the appearance of the scheme as a whole. The architecture, however, is very pleasing, and shows what can be done even when economy is the dominating factor.


Composite jointless floor finish ½ thick
Reinforcement in floor
4½
Damp Course
A STANDARD CONCRETE BLOCK COTTAGE WALL
8'9" Floor to Floor
Wall ties
4⅞
11/16
Damp Course
Composite jointless floor finish

Details of Wall.
Concrete Cottages at Braintree.

The site is an ideal one for concrete construction. Clean sand and gravel, which do not require washing, are excavated on the spot by a steam navvy, and after being screened are hauled on trucks by a winch direct to the mixer. The block-making machines were made specially for the contractors, and turn out about 925 blocks per eight-hour day with three operatives. Moulds are filled with the mix at both ends of the machine, and then alternately pushed along rails to the centre, where the pressure is applied by the third operative. Thus, while one mould is being filled the other is being compressed, and the operation is continuous. Each block is equivalent to six bricks, with a resultant saving of labour and mortar.

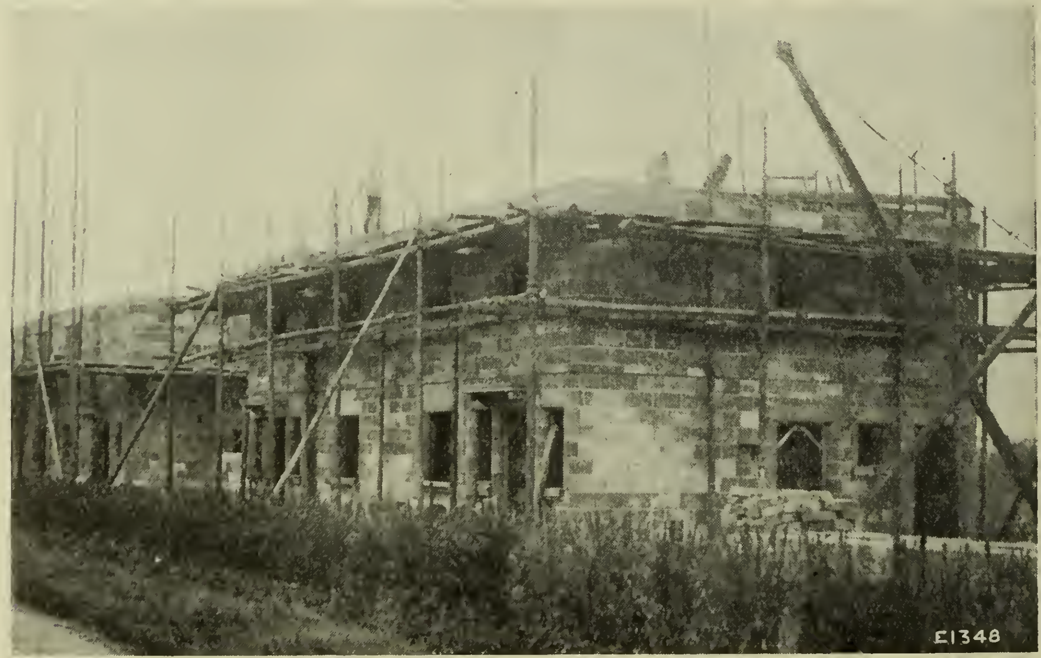


Reproduced by the courtesy of The Builder

Concrete Cottages at Braintree.

The principle adopted for the construction eliminates all cutting of blocks and waste, and for fuller particulars of this system we would refer our readers to our May issue. All doorways, window openings, etc., are standardised to multiples or fractions of the unit.

The foundations are of concrete, 9 in. thick, and a damp-course consisting of two layers of slates set in cement is provided. The external walls and party walls are built hollow of two 4⅛ in. walls of concrete blocks, with a cavity of approximately 2 in., tied together with wrot-iron or steel ties at 3 ft. intervals at alternate courses. A continuous air-current is provided by ventilation gratings fixed immediately above the damp-course and under the eaves. The internal walls are solid, of 4⅛ in. blocks. The ground and first floors are of 5 in. and 4½ in. concrete respectively, the latter reinforced with expanded metal. The roof is of 7-in. reinforced concrete, covered with tar. With the exception of the scullery and larder, all the floors are covered with a pleasing red jointless composition, which can be polished. Inside the walls are plastered and distempered ; in the two inhabited houses, however, the ceilings upstairs are left just as the boards were taken away after the concrete had set.



A Cottage in course of construction at Braintree.

The interiors present many novel features, and except for the interior doors, the use of wood has been entirely eliminated. Internal steel doors are also to be fitted at a later date. The window sashes, front and back doors, internal door frames, staircases, built-in cupboards, dresser and mantel-shelves are all of pressed steel, painted green. With the present high cost of timber, and the comparative speed and cheapness with which metal fittings can be produced when standardised and manufactured in bulk, this is an important factor with regard to economy. Also, the fire risk is practically nil, and it is claimed that the houses are proof against draughts, damp and vermin. The windows are of the casement type.

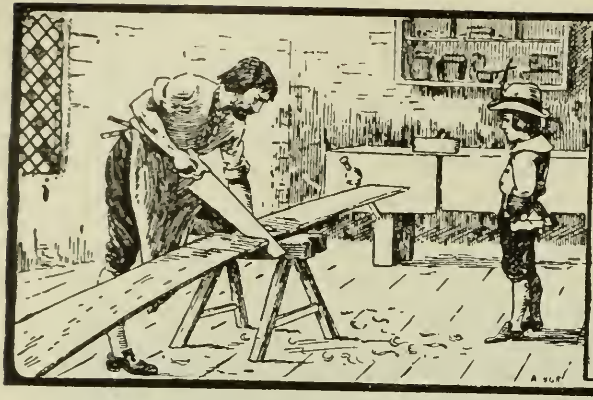
The plan of the houses is compact and convenient. The ground floor consists of hall, parlour, living-room, scullery and larder (under stairs) ; the upper floor contains three bedrooms, bathroom, and a large clothes cupboard. The living room is fitted with a large range and dresser ; the scullery contains the sink, copper and gas cooker ; the other rooms have open grates. All the hearths are finished with tiles or coloured cement. The areas of the rooms do not quite come up to the standard of the Tudor Walters' Report, but, especially in the case of the living rooms, are of ample dimensions. The coal store and w.c. are built of concrete, and situated outside. The ground between these two outbuildings is concreted and covered in, and can be used as a store for cycles or garden tools. A further portion of the yard is concreted, and used as a drying ground.

A Factory in course of construction at Braintree.

The cost of these houses works out at £718, or, without outhouses and cement courts, with w.c. in bathroom, and coal store outside, at £678. Similar houses with slate roofs cost £746 and £706 respectively. These prices are subject to suitable working conditions, cement being obtainable at 80s. per ton on site, aggregate at 5s. per yd. cube at the mixer, brick-layers at 1s. 6d. per hour, labourers at 1s. 2d. per hour, and are for schemes of not less than one hundred houses. With good conditions, one hundred houses can be erected in seven months on a large scheme.

Mr. C. H. B. Quennell, F.R.I.B.A., acted as architect in connection with the Braintree Co-operative Homes, Ltd., in conjunction with Mr. W. F. Crittall.

The system has great possibilities for the speedy erection of houses in large numbers, and in view of the urgency of the housing question, speed is of the utmost importance. It is doubtful whether the timber-frame houses so widely advocated in the daily Press at the present time could be shipped and erected in this country more quickly than these concrete houses, and the ultimate cost would not be much less. If any saving at all were effected in the first instance, it would quickly be absorbed by upkeep charges, which in the case of houses built of concrete and steel is practically negligible.



AN AID IN FORM WORK.

The following notes and illustrations on economising in the use of timber for form work may prove useful, especially at the present time, when timber is still very expensive and difficult to get.—ED.

In construction of reinforced concrete work the cost of the temporary wooden shutters or forms is often so high as to become one of the most important elements in the cost of the work. A structure of large dimensions cannot be carried on quickly without employing for a long time enormous quantities of timber, the value of which, when the work is completed, cannot be entirely recovered, as the timber will be in such a state that its value is reduced to a great extent.

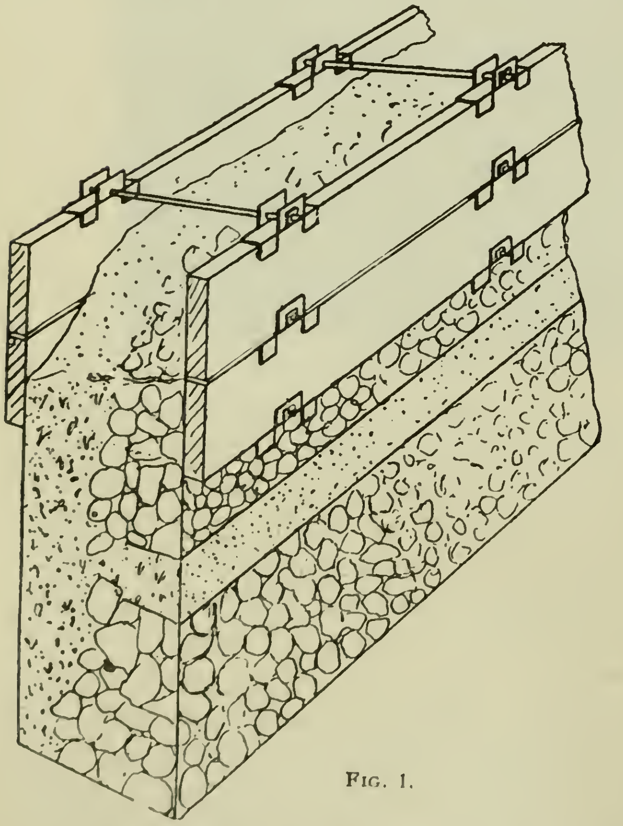


Fig. 1.

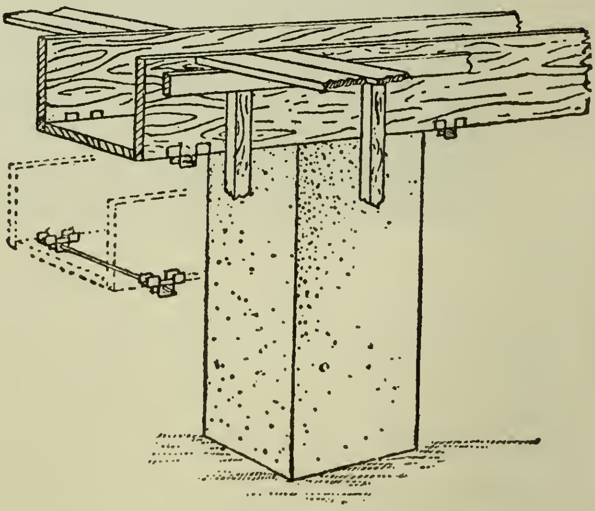


Fig. 2.

To overcome this difficulty an American builder has suggested the use of *plank holders*, which greatly reduce the quantity of timber and enable it to be used repeatedly because the operations of mounting and dismounting are simplified.

The plank holders or clamps are made of thin metal rolled cold, and if made with care will last indefinitely. *Fig.* 3 shows three types A, B, C, and with proper combinations of these holders he can erect forms for walls of any height, for floors of any shape, or for work of any kind, without using any nails or side supports and with a saving of 75 per cent. on the usual methods.

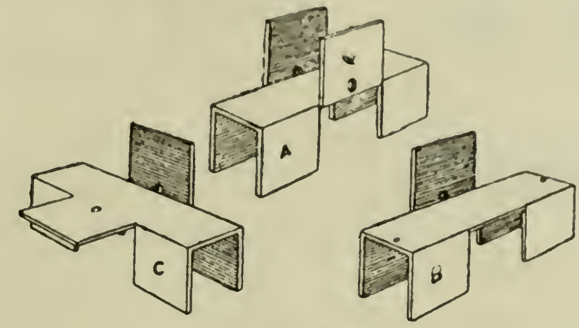
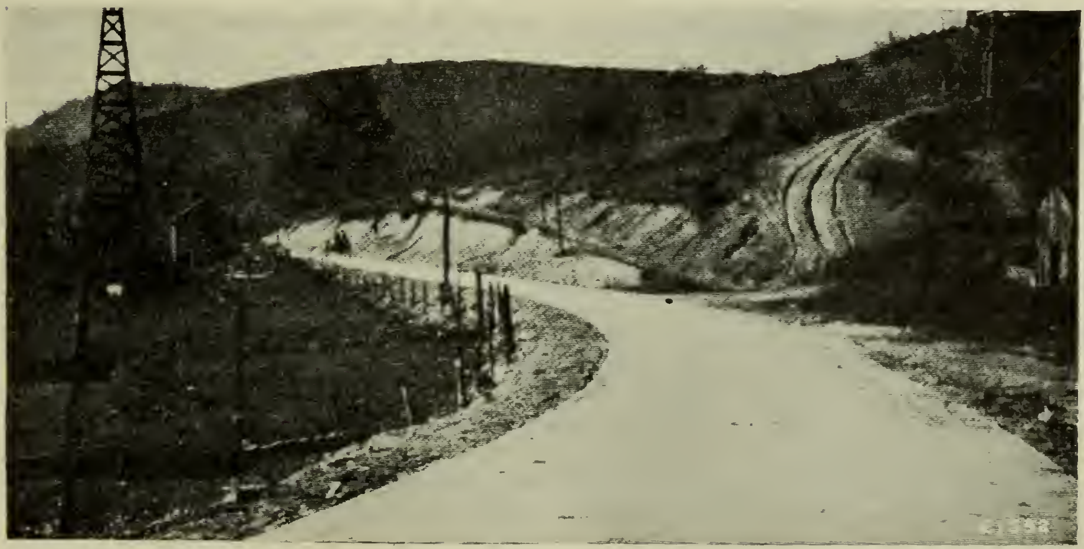


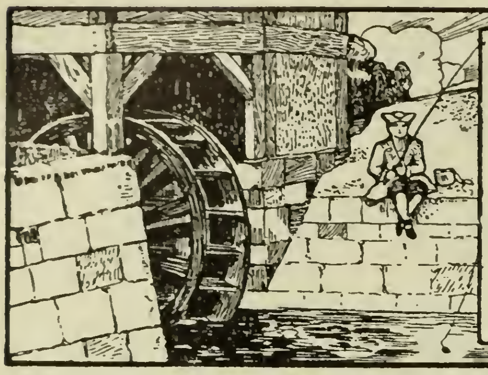
FIG. 3.

A glance at *Fig.* 1 shows clearly the method of employing the clamps in the building of walls. They are fixed in pairs at the end of a short bar at a distance corresponding to the thickness of the walls. To hold the first row of planks in place clamps of the B type are used, because this allows the removal of the planks placed between the ground and an upper row of other planks. For the other rows type A is used ; type C being used to support planks at right angles, as for floor beams in the building of pillars.

Fig. 2 shows a method of preparing the shuttering for a floor without nails ; when the beams are of greater height than that of one plank, other clamps are placed as in the building of a wall so as to reach to the required height.



A CONCRETE ROAD IN MARION COUNTY, W. VA., U.S.A., IN WHICH NO EXPANSION JOINTS WERE USED.



STANDARD SPECIFICATION FOR COTTAGES.

(*Continued from October issue.*)

71. *Hips and Valleys.*—The hips and valleys are to be formed with proper hip and valley tiles coursed and bonded with the ordinary tiling and nailed at every course. The hip tiles are to be bedded in hair mortar and pointed in cement mortar.

72. *Soakers.*—Fix the lead soakers provided by the plumber.

73. *General.*—Make good all damage done to the tiling, and at completion leave all roofs sound and watertight, and clean out eaves, gutters and downpipes. N.B.—Bridgewater, Roman or pantiles may be used where customary, and the specification varied accordingly.

SLATER.

74. *Slates.*—Slates should not be used for roofs with a pitch of less than 30 deg. The slating is to be of outsizes of good quality Welsh or local slates free from defects, laid with a lap of not less than 3 in. throughout, each slate being fixed with two 2 in. stout composition nails to 2 in. by 1 in. battens. Where no fascia or soffit boards are provided the slates are to be nailed to 1 in. rough boarding between the eaves and wall plate. All slating may be pointed or torched on the underside in the manner customary in the district.

75. *Verges.*—Trim and point the verges in cement and fix an extra course of slates under verges.

76. *Eaves.*—Put a double course of slates at all eaves, bedded in cement mortar.

77. *Ridges and Hips.*—Cover the ridges and hips with half-round or other approved section blue tiles bedded down solidly in hair mortar and pointed in cement mortar. Fill in open ends with plain tiles in cement.

78. *Soakers.*—Fix the lead soakers provided by the plumber.

79. *General.*—Make good all damage done to the slating, and at completion leave all roofs sound and watertight and clean out eaves, gutters and downpipes.

CARPENTER AND JOINER.

80. *Thicknesses.*—The thicknesses of all joinery specified are before planing, and one-sixteenth inch will be allowed for each wrought face from all specified thicknesses.

81. *Storing Joinery.*—All joinery immediately after delivery at the site is to be stored and protected from the weather. The floor boards are to be stacked on the site face downwards within a month of commencement of the work, and to be protected from the weather at least one month before use.

82. *Painting Joinery Previous to Fixing.*—All joinery specified to be painted is to be knotted and primed before leaving the joiner's shop. The bottom edges of all doors are to be primed and painted one coat just previous to hanging. The backs of all window frames and back linings and the backs of external door frames are to be coated with one coat of creosote or other approved material. (See also "Painter.")

83. *Materials for Carcassing.*—The timber used is to be sound redwood or white wood of suitable building quality, and not inferior to good fourth Swedish classification ; or equal quality in Finnish or Russian production, spruce, red pine, pitch pine, Oregon pine or British Columbia pine. All to be reasonably seasoned. Wrack and dead wood will not be permitted.

84. *Home-Grown Timber for Carcassing.*—Oak, chestnut, larch, spruce, or Scotch fir may be used for carcassing, if of an approved quality and growth and felled during the winter months. All to be reasonably seasoned. Wrack and dead wood will not be permitted. The scantlings are to be similar to those specified for imported timber, except in the case of oak and chestnut, when the scantlings can be reduced 1 in. in depth. Oak or chestnut beams may be used to support the first-floor joists which may then be of the scantlings suited to the reduced span.

85. *Materials for Joinery.*—The timber used is to be sound redwood or whitewood of suitable joinery quality, and not inferior to good third Swedish or White Sea classification, or equal quality

in Finnish or Russian production, red pitch pine, Oregon pine or British Columbia pine. All may be used for both external and internal work, with the exception of whitewood and yellow pine, which may only be used for internal work. All the wood must be seasoned and dry. Wrack and dead wood will not be permitted.

86. *Timber Generally.*—All timber is to be cut square free from excess of wane or discoloured sapwood. N.B.—These descriptions of materials for carcassing joinery will only apply during the period of scarcity of timber. As the supplies improve, fresh descriptions will be issued.

87. *Sills.*—The oak or chestnut used for sills is to be free from sapwood, dead knots, or other defects, and to be well seasoned and dry.

88. *Framed Work.*—All doors and other framed work are to be put together immediately upon the general work being commenced, but not to be glued and wedged up until the joinery is prepared in readiness for immediate fixing. All framing is to be put together with well-fitting mortise and tenon joints wedged up solid.

89. *Ground Joists and Sleepers.*—Where there are not solid lower floors there are to be ground joists on 4 in. by 1¼ in. fir sleepers about 6 ft. apart, which are to be bedded down upon the honeycomb 4½ in. brick sleeper and fender walls and kept 1 in. clear of all external walls ; these sleepers are to be coated with one coat of creosote all round before bedding.

90. *Floor Joists.*—Construct the wood floors with joists of the following scantlings or with joists of equal area and suitable depths :

Depth in inches when the breadth of joists is :

	2 in.	2½ in.	3 in.
Length of the bearing not exceeding 5 ft.	4	—	—
,, ,, ,, 6 ft.	4½	4	—
,, ,, ,, 8 ft.	5½	5	4½
,, ,, ,, 9 ft.	6	5½	5
,, ,, ,, 10 ft.	6½	6	6
,, ,, ,, 11 ft.	7	7	6
,, ,, ,, 12 ft.	8	7	7

The upper floor joists are to bear direct on the brick walls without wall plates. The ends of the joists are to be bedded up level and carefully brick-filled between the ends. All floor joists are to be fixed at spacings not exceeding 14 in. apart, and each joist is to have a full wall bearing at each end. The trimmers and the trimming joists are to be ½ in. thicker than the other joists. All the floor timbering is to be properly trimmed and tusk tenoned. Filleting is to be put around the hearth trimmings for receiving brick or concrete hearths.

91. *Cross Strutting.*—Put one row of 1½ in. by 1½ in. sawn herring-bone strutting to all bedroom floors where the bearing of the joists exceeds 8 ft. Solid strutting will be permitted.

92. *Flooring.*—Lay the wood floors with 1 in. straight joint or ploughed and tongued (according to local custom) floor boards of varying widths, thoroughly seasoned, well jointed and securely fixed to each joist with two 2¼ in. brads well punched down. All the flooring is to be well cleaned off and protected. Put properly mitred margins around all the hearths.

93. *Suspended Concrete Floors and Floor Finishings.*—Suspended concrete floors may be used to the upper floors, formed of hollow blocks with reinforced concrete between or with reinforced beams and reinforced cast concrete slabs of the necessary strength to suit the bearings, or other approved form of construction. Details must be given of the form of construction intended. The finishing to the ground floors of parlours and living rooms and to the first floors where suspended concrete floors are utilised may be formed with approved composition flooring or screeded with 1 in. thickness of Portland cement and sand (gauged 1 and 3), finished perfectly smooth and hard with a steel trowel. These finishings are not to be executed until just before the houses are completed. The composition flooring is to be polished with wax or other approved preparation.

94. *Ceiling Joists.*—The ceiling joists are to be 2 in. in thickness, spaced not exceeding 14 in. apart, not less than 4 in. or more than 5 in. deep, trimmed properly around trap doors and stacks, with stiffeners 5 in. by 1 in. and hangers 3 in. by 1½ in. wherever required fixed to purlins and rafters.

95. *Roofs.*—Construct the whole of the roofs with timbers of the following scantlings or of equal area and suitable depths :

Rafters spaced not exceeding 14 in. apart.

		Dimensions.
Length of bearings not exceeding 5 ft.	...	3 in. by 2 in.
,, ,, ,, 6 ft.	...	3½ in. by 2 in.
,, ,, ,, 7 ft.	...	4 in. by 2 in.
,, ,, ,, 8 ft.	...	4½ in. by 2 in. or 4 in. by 2½ in.
,, ,, ,, 9 ft.	...	5 in. by 2 in. or 4½ in. by 2½ in.

Hips and valleys are to be 9 in. by 2 in. or 11 in. by 1½ in. and ridges 7 in. by 1½ in. Put 1 in. boarding to valleys in slated roofs. The roofs are to be stiffened with the necessary collars and struts to carry 5 in. by 3 in. purlins at intervals of about 6 ft. The rafters are to be notched and spiked to the wall plates, purlins, and ridges. The ceiling joists are to be spiked to the rafters and ceiling beams.

96. *Fascias.*—A wrought fascia board 5 in. by 1 in. may be used spiked to the feet of the rafters to serve as a tilt for the tiling or slating with ¾ in. soffit boarding on suitable bearers ; or the brackets to eaves gutters may be screwed to the sides of the projecting rafters. Where no soffit boarding is intended, the battens on backs of projecting rafters are to be omitted and 1 in. boarding is to be fixed instead. The feet of rafters and soffit of roof boarding where projecting are to be treated with one coat of approved wood preserving stain as described in " Painter."

97. *Projecting Eaves.*—Eaves should not project more than 12 in. beyond the face of the wall.

98. *Wood Fixing Slips, etc.*—Deal fixing slips are to be built in dry in the joints of brickwork or walling, or otherwise coke breeze bricks are to be built in for fixing joinery.

99. *Skirtings.*—Put 3½ in. by ¾ in. chamfered skirtings plugged to walls over all wood or composition flooring. 1½ in. by 1½ in. quadrant skirting fillet may be used in place of the above skirting.

100. *Chair Rails.*—Put to living rooms a 3½ in. by ¾ in. wide chamfered chair rail plugged to wall at a height of 2 ft. 6 in. from floor to bottom of rail.

101. *Picture Rails.*—Put around the living rooms, parlours, and bedrooms a picture rail 1 in. by 1½ in. plugged to walls. As an alternative picture rail, a light steel tube with sleeve brackets, finished black, pinned into walls and carried across window as curtain rod, may be used.

102. *Cloak Rails.*—Cloak rails 6 ft. long 1 in. by 4 in. plugged to walls are to be fixed where indicated, and six hat and coat hooks are to be screwed thereon.

103. *Air Grids.*—Provide and fix in the larder flyproof perforated zinc cover over the air brick fixed to small wood beading. Where air bricks are provided to bedrooms, they are to be fitted with wooden hoppers.

104. *Windows.*—All windows should be fixed close to the external wall face.

105. *Double Hung Sashes and Frames.*—The sash frames for double-hung sashes are to have 7 in. by 3 in. weathered and checked oak or chestnut sills, throated on underside, 4½ in. by 1 in. deal pulley stiles and heads, 4½ in. by 1 in. outer linings, extended where there are arches over, 3 in. by ¾ in. inner linings, 1 in. by ¾ in. inside beads, 5 in. by ½ in. back linings, 1¾ in. by ¼ in. parting slips, 1 in. by ½ in. parting beads, and 2½ in. by 1 in. draught boards. The sashes are to have 1¾ in. by 3½ in. bottom rails, 1¾ in. by 2 in. top rails and stiles, 2¼ in. by 1½ in. meeting rails, and 1¾ in. by 1¼ in. square, chamfered, or moulded bars. The sashes are to be hung on stout cords with iron weights, and to have 1¾ in. brass-faced axle pulleys.

106. *Casements.*—The casement frames are to have 6 in. by 3 in. weathered and checked oak or chestnut sills, throated on underside, and 4 in. by 2 in. deal frames and mullions, with ¾ in. rounded stops planted on and mitred, with casements fixed or hung therein, having 2 in. by 1¾ in. top rails and stiles, 3 in. by 1¾ in. bottom rails, and 1¾ in. by 1¼ in. squared, chamfered, or moulded bars.

107. *Yorkshire Windows.*—Yorkshire windows are to have 6 in. by 3 in. weathered and checked oak or chestnut sills, throated on underside, 4 in. by 2 in. deal frame with ¼ in. parting bead, ¾ in. sash beads, and ¾ in. by ½ in. hardwood runner let into sill, with sashes similar to last, some of the sashes being fitted to slide. Fit each sliding sash with 3 in. japanned iron cabin hook on plate and two eyes.

108. *Skylights.*—Where no windows are provided to staircases, supply and fix a standard pattern cast iron ventilating glazed skylight fixed on the battening before the roof covering is put on. Trim and form opening rafters and in ceiling joists and form well-hole with 3 in. by 2 in. timbers from ceiling joists up to soffit of rafters and line with lath and plaster or fibrous slab as described in " Plasterer."

109. *Steel Windows.*—Where these are made use of they are to be as specified in " Founder and Smith," set solidly and pointed up in cement as the work proceeds.

110. *Cover Fillets.*—Put 1 in. by 1 in. quadrant rounded or moulded cover fillets internally and externally around windows after the plastering is completed and before finishing coat of roughcast or harling is applied.

111. *Window Boards.*—The windows are to have 1 in. deal rounded window boards tongued to oak sill, or the sills can be finished with red quarry tiles set and pointed in cement mortar.

112. *Doors Generally.*—The doors are to be of a uniform height, and all doors giving access to rooms and cupboards are to be 2 ft. 8 in. wide, the doors to w.c.'s, e.c.'s, larders, coal stores, and outbuildings are to be 2 ft. wide.

113. *Front Doors.*—The front doors are to be 1¾ in. thick, with 4½ in. top rails and stiles, 9 in. lock and bottom rails, 1¼ in. lower panels, bead and butt flush on the outside, 1¾ in. by 1¼ in. squared, chamfered or moulded glazing bars in the upper panel, and ½ in. ovolo moulded glazing beads. Screw on 1½ in. by 3 in. shaped weather fillet let into the bottom rail of door, the full width of door, the frame to be notched for same, and the ends of the weather fillet slightly splayed. These doors are to be hung

with three 4 in. butts to 4½ in. by 3 in. rebated and moulded frames, the heads having 4 in. horns for building into the walls.

114. *Back Doors.*—The back doors are to be 1¾ in. framed and ledged doors, having 4 in. by 1¾ in. or 4½ in. by 1¾ in. stiles, 9 in. by 1 in. or 8 in. by 1 in. middle and bottom rails, and 1 in. tongued grooved and V-jointed boarding, in widths not exceeding 5 in., each hung with three 4 in. butt hinges to 4½ in. by 3 in. rebated and moulded frames, the heads having 4 in. horns for building into the walls.

115. *Internal Doors.*—The internal doors are to be 1½ in. four-panel square doors, with 9 in. by 1½ in. or 8 in. by 1½ in. lock and bottom rails, 4½ in. by 1½ in. or 4 in. by 1½ in. top rails muntins and stiles, and ¾ in. panels, hung with pair of 3 in. butts to 6 in. by 1¼ in. lining, with 3 in. by ½ in. stops for 4½ in. walls, or 4 in. by 1½ in. frames with 2 in. by ½ in. stops for 3 in. slab concrete partitions. The frames are to be grooved ¼ in. deep at back to receive edge of concrete partitions, and they are to be carried up and securely fixed to the ceiling joists at top and to the floors at feet.

116. *Ledged and Braced Doors.*—The coal store and w.c. or e.c. are to have 1 in. ledged and braced doors, with 7 in. by 1¼ in. ledges, 4½ in. by 1¼ in. braces, 1 in. tongued groove and V-jointed boarding, and hung with 14 in. Tee hinges to 4 in. by 2 in. frames with ¾ in. rounded stops planted on.

117. *Iron Dowels.*—Put ⅝ in. wrought iron dowels 4 in. long between feet of frames of external doors and thresholds under same. The dowels are to be galvanised after being cut to lengths.

118. *Fanlights.*—Provide and fix over internal doors wherever required 1½ in. moulded fixed fanlight and glaze same with 15 oz. sheet glass, the linings and frames of doors being carried up to receive same.

119. *Architraves.*—Provide and fix around doorways ¾ in. by 2½ in. moulded, rounded or chamfered fillet as architraves.

120. *Dressers.*—In districts where dressers are usually provided in living rooms, they are to be constructed with 1¼ in. table top 18 in. wide, and the part below same enclosed and fitted with 1¼ in. square doors hung with pair of 2 in. butts and fitted with iron butterfly turnbuckle and staple, 1 in pot board and bearers, and 1 in. shelf in enclosed portion with drawers 7 in. high having 1 in. beaded front and ¾ in. rims dovetailed together, and ¾ in. bottom on proper runners, the part above table top to have two 1¼ in. diminished standards, three 1 in. grooved shelves with fillet at back plugged to wall as bearer the full length of shelves, and 1 in. top with 1 in. by 1½ in. cornice. Provide and fix to each drawer two plain blacked iron handles, and to shelves two dozen brass cup and jug hooks. Where it is usual for tenants to provide their own dressers, a suitable place or recess is to be formed to receive them.

121. *Staircase.*—Construct the staircase with 1½ in. treads, with rounded nosing, and 1 in. risers, tongued in both edges and glued, blocked, and bracketted on stout fir carriages, 1¼ in. square wall strings and 1½ in. outer strings framed to 3 in. newels with shaped or turned top. The staircase enclosed between walls are to have 2 in. by 1¼ in. hollowed wall handrail screwed to plugs in wall, and staircases open on one side are to have 3 in. by 2 in. American whitewood oval handrail fixed to 1 in. deal square balusters spaced two per step. Where stairs are open on one side, enclose the space under same with ¾ in. matched and V-jointed boarding nailed to fir bearers to form cupboard and form a ledged door hung with pair of 8 in. wrot iron strap hinges to 3 in. by 2 in. deal frame and fitted with straight cupboard lock.

122. *Cupboards.*—The cupboards are to be formed in 3 in. concrete slabs, with the partitions carried up to the ceiling with 1½ in. doors and frames as previously described for internal doors, except that the doors are fitted with 1½ in. iron button on plate and 1½ in. iron knob. Provide and fix 5 ft. above floor one ¾ in. shelf on chamfered bearers and ¾ in. by 5 in. chamfered hat rail under shelf with japanned malleable iron wardrobe hooks spaced 9 in. apart.

123. *Linen Cupboard.*—The linen cupboard is to be formed as last described and fitted with three tiers of slat shelving of ¾ in. by 2 in. slats spaced 1½ in. apart on chamfered bearers.

124. *Shelving.*—Provide and fix above the slate or stone shelving in larder three tiers of 1 in. deal shelving, one 11 in. and two 9 in. wide, on chamfered bearers. Provide and fix 50 ft. run of 1 in. by 9 in. shelving in suitable positions upon deal gallows brackets, or stamped steel brackets, and 30 ft. of pin rails.

125. *Coal Boards.*—Provide for coal store four 1 in. by 9 in. coal boards 3 ft. high to slide in rebated runners nailed to door frame.

126. *Draining Board.*—Provide and fix at side of sink 1 in. beech or sycamore, ledged and grooved, draining board, with ¾ in. by 3 in. skirting next walls, fixed on deal bearers and gallows brackets where required.

127. *Trap Door.*—Provide in ceiling over staircase a 1 in. deal ledged trap door 2 ft. by 2 ft. for access to roof, with 1 in. beaded lining around. The lining is to be ½ in. deeper on two opposite sides, so as to keep the trap door ½ in. up for ventilation ; the trap door to be secured with two bolts.

128. *Clothes Posts.*—Provide two 4 in. by 3 in. wrot clothes posts 10 ft. long each with two turned

hardwood or iron pins at top. Set the feet of posts into the ground 2 ft. 6 in. deep, and nail on 1 in. rough bases 9 in. high mitred around between earth and air, and once creosote same before fixing.

129. *General.*—Provide and fix all blocks, plugs, &c., required, and do everything necessary to complete the carpenters' and joinery work to the satisfaction of the architect.

IRONMONGERY.

130. *General.*—The ironmongery generally is to be of the approved standard patterns. All brass fittings are to be fixed with brass screws. All butts are to be best quality pressed steel butts. The keys of all locks and night latches to external doors are to differ for each cottage.

PLASTERER.

131. *Lime.*—The lime for plastering is to be well burnt stone or chalk lime, and it is to be run into putty at least one month before use.

132. *Sand.*—The sand for plastering is to be clean, sharp, river or pit sand, free from earth, loam or saline materials, and well screened.

133. *Hair.*—The coarse stuff throughout is to have 9 lb. of good long hair, free from grease or other impurities, well beaten up and mixed with every cube yard of the coarse stuff. If mill-ground coarse stuff is made use of, the hair is to be added after grinding.

134. *Laths.*—The laths are to be rent of single lath or sawn lath and half strength ; each lath is to be properly secured with 1 in. wire nails to each ceiling joist, butt-jointed, and to break joint every 3 ft.

135. *Cement.*—The Portland cement is to be as previously described.

136. *Proportions of Materials.*—For the coarse stuff one part of lime is to be well mixed with three parts of sand by measure, and in this is to be incorporated 9 lb. of hair with every cube yard. For the setting coat not less than one part of lime putty is to be well mixed with one part of clean sand.

137. *Ceilings and Soffits.*—Lath and plaster with two coats the whole of the ceilings, sloping ceilings, and the soffits of the staircases wherever they are exposed. Fibrous plaster seasoned slabs ⅝ in. thick cast with a rough surface for plastering, fixed with 1½ in. composition nails 4 in. centres, and finished with a setting coat may be used in place of last.

138. *Float and Set.*—Float and set the whole of the interior walls and partitions, excepting in scullery, larder, coal store, w.c., e.c., back entrance lobby, and outbuildings. If fair face cannot be produced with the bricks available, the walls of scullery and larder are to be plastered in Portland cement and sand gauged one to three to a height of 4 ft. 6 in. above floor as dado finished with splayed top edge. In all cases the plastering on walls and partitions is to be continued down to the floor levels.

139. *Salient Angles.*—The external angles throughout the plastered walls are to be slightly rounded, and the first coat of plastering thereon is to be gauged with cement.

140. *Cement Skirting to Sink.*—Put Portland cement skirting to sink where it abuts against walls up to the window sill, or otherwise 9 in. high, trowelled to a smooth and impervious face ; or glazed tile skirting may be used.

141. *Covering Cavities.*—Where hollow walls are plastered, put rough pieces of slate or tile to the reveals and sills set in cement to cover wall cavities as necessary.

142. *Roughcast, &c.*—Where indicated on drawings float in cement and sand on to three not less than ½ in. thick, well score the same and finish with a cement face roughcast or harled.

143. *General.*—Make good after all other trades and leave the plasterer's work perfect on completion.

FOUNDER AND SMITH.

144. *Eaves Gutters.*—The eaves gutters are to be cast iron beaded, half-round standard pattern, the joints made in red lead and bolted, fixed on standard galvanised wrought iron or galvanised stamped steel brackets, two to each 6 ft. length of gutter, with spiked ends for driving into the concrete eaves course, or screwed to the feet of the rafters, sprocket pieces or fascias. Provide all requisite cast angles, stopped ends, and outlets with nozzles.

145. *Fall Pipes.*—All the fall pipes are to be cast iron standard-pattern piping with projecting ears to keep pipes 1 in. clear of the walls, fitted with all necessary swan-necks, shoes and heads, and fixed with 3 in. rose-headed nails.

146. *Steel Casements.*—Where steel windows are intended to be used, they must be of approved standard pattern with lugs bolted on for building into walls.

147. *Stoves and Ranges.*—The stoves are to be generally of the mantel register type selected from standard patterns. The ranges are to be of standard patterns.

148. *Dustbin.*—Provide and place in position a standard galvanised-iron sanitary dustbin 18 in. diameter and 24 in. high, complete with cover.

PLUMBER.

149. *Materials and Workmanship.*—All the lead used is to be the best milled lead, and of the full weight specified. The running joints in lead pipes and the joints to fittings are to be wiped soldered joints.

150. *Chimney Aprons.*—The aprons of the lower sides of the chimney stacks are to be 4 lb. let ¾ in. into the joints of the brickwork or walling, to be brought not less than 3 in. down the chimney side, and to lie 6 in. on the tiles or slates, secured with lead wedges and pointed in cement, well worked round the returns of the stacks, and there covered with the over flashings.

151. *Gutters.*—Lay the gutters behind chimney stacks (where required) with 5 lb. lead turned up 4 in. against brickwork and 8 in. under slates or tiles, and not less than 6 in. wide on sole at narrowest part.

152. *Soakers.*—In all cases where the raking line of tiling or slating meets brickwork or walling, 3 lb. lead soakers are to be fixed one to each slate or tile, turned up 3 in. against the walls and lying 5 in. on the slating or tiling, and to be 3 in. in addition to the full gauge of the tiles or slates.

153. *Flashings and Valleys.*—The lead soakers are to be covered with 4 lb. lead stepped flashings 8 in. wide, turned ¾ in. into the joints of the brickwork or walling secured with lead wedges, and pointed in cement. The straight flashings are to be similar, but 6 in. wide. Lay the valleys in slated roofs with 4 lb. lead 15 in. girth.

154. *Water Service.*—Lay on water service to house in accordance with the local regulations with either lead pipe or galvanised wrought iron steam tubing as required, and connect with the public water main. Provide a screw-down stop-cock fixed inside each house, easy of access, where the main supply enters the house, and one on the down service just under the cistern.

155. *Cistern.*—Carry a ½ in. rising main up to a 40-gallon standard galvanised iron cistern fixed on sufficient bearers, and take ½ in. branch pipes from the rising main direct to the sink, bath, copper, lavatory basin, and water waste preventor.

156. *Ball-cock.*—Provide and fix ball-cock over cistern.

157. *Warning Pipe.*—Provide and fix an iron or lead warning pipe connected to cistern of sufficient size, discharging in an exposed position outside with copper hinged flap on end.

158. *Wastes.*—From the sink and lavatory basin take 1¼ in. and from the bath take 1½ in. iron waste pipes to the open, connected to the traps of the fittings and discharging over gullies or hopper heads.

159. *Rainwater Butts.*—Wherever rainwater butts are shown on the plans they are to be 40 gallon petroleum casks, well burnt out, and twice tarred externally, fitted with a 1 in. deal ledged cover twice tarred, perforated for the inlets. A 1¼ in. iron overflow is to be fixed to the cask connected by an elbow with screwed and jointed washers to the barrel to discharge over an adjacent gully or otherwise carried to a point at least ten feet away from the building where a soakaway is to be made one yard cube in all.

160. *Soil Pipes.*—All the soil and ventilating pipes are to be 3½ in. cast-iron standard pattern dipped in Dr. Angus Smith's solution, with projecting ears fixed with 3 in. rose-headed nails, the joints caulked and run with blue lead or caulked with lead wood. The branch soil pipes and junctions are to be of standard pattern. The ventilating pipes are to be carried up 2 ft. above the roof or the top of the nearest dormer window, through the eaves of roof where these occur, flashed with a 5 lb. lead tile or slate soldered to the iron pipes tinned for the purpose, and terminated with a copper-wire balloon grating. The trap of w.c. is to be connected to the socket of the branch pipe and caulked with gaskin and jointed in red lead. The feet of soil and ventilating pipes are to be connected direct to the salt-glazed ware bend and caulked with gaskin and jointed in Portland cement and sand gauged 1 to 3.

161. *Bath and Lavatory Wastes.*—The external wastes to the bath and lavatory basin on the first floor are to be 2 in. cast-iron standard pattern, all as described for soil and ventilating pipes, but jointed in red lead and tow, with hopper heads to receive the discharge pipes at the top and shoe at bottom to discharge over gully.

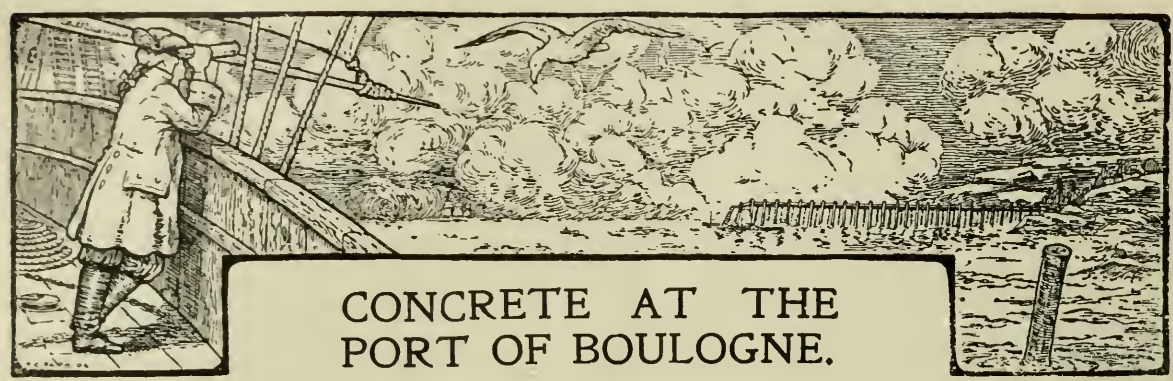
162. *W.C. or E.C.*—The w.c. is to be a stoneware pedestal closet with water-waste preventor with 1¼ in. galvanised steel flush-pipe and 1¼ in. plain hardwood seat, unpolished, in one thickness all to approved pattern. The flush-pipe is to be jointed watertight to the flushing arm of the w.c. Put ½ in. wrought-iron overflow to the water waste preventor carried through the external wall with a projection of 6 in. The e.c. is to have a strong galvanised iron sanitary pail with handles, and is to be fitted with 1¼ in. seat with properly dished hole on 5 in. by 1¼ in. bearers.

163. *Washing Copper.*—Washing copper, see " Bricklayer." Provide and fix over copper ½ in. bib cock.

164. *Sink.*—Sink, see " Bricklayer." Provide and fix over sink two ½ in. bib cocks marked " Hot " and " Cold " respectively.

165. *Lavatory Basin.*—The lavatory basin is to be glazed stoneware with overflow, brass waste, plug, and chain, and hot and cold taps, and iron trap, and is to be fixed on brackets or bearers, the whole to standard pattern.

(*To be Continued.*)



CONCRETE AT THE PORT OF BOULOGNE.

We give below a brief description of the concrete work which has been carried out in connection with the extension at the Port of Boulogne.—ED.

THE port of Boulogne, which has long been the most important fishing harbour on the Continent, and in the world second only to Grimsby, has also to deal with complex problems respecting the transport of transatlantic and other travellers and merchandise, and as they cannot be completely separated, the manner in which provision has been made for these various requirements is a tangible indication of the progressiveness of the Port Authorities.

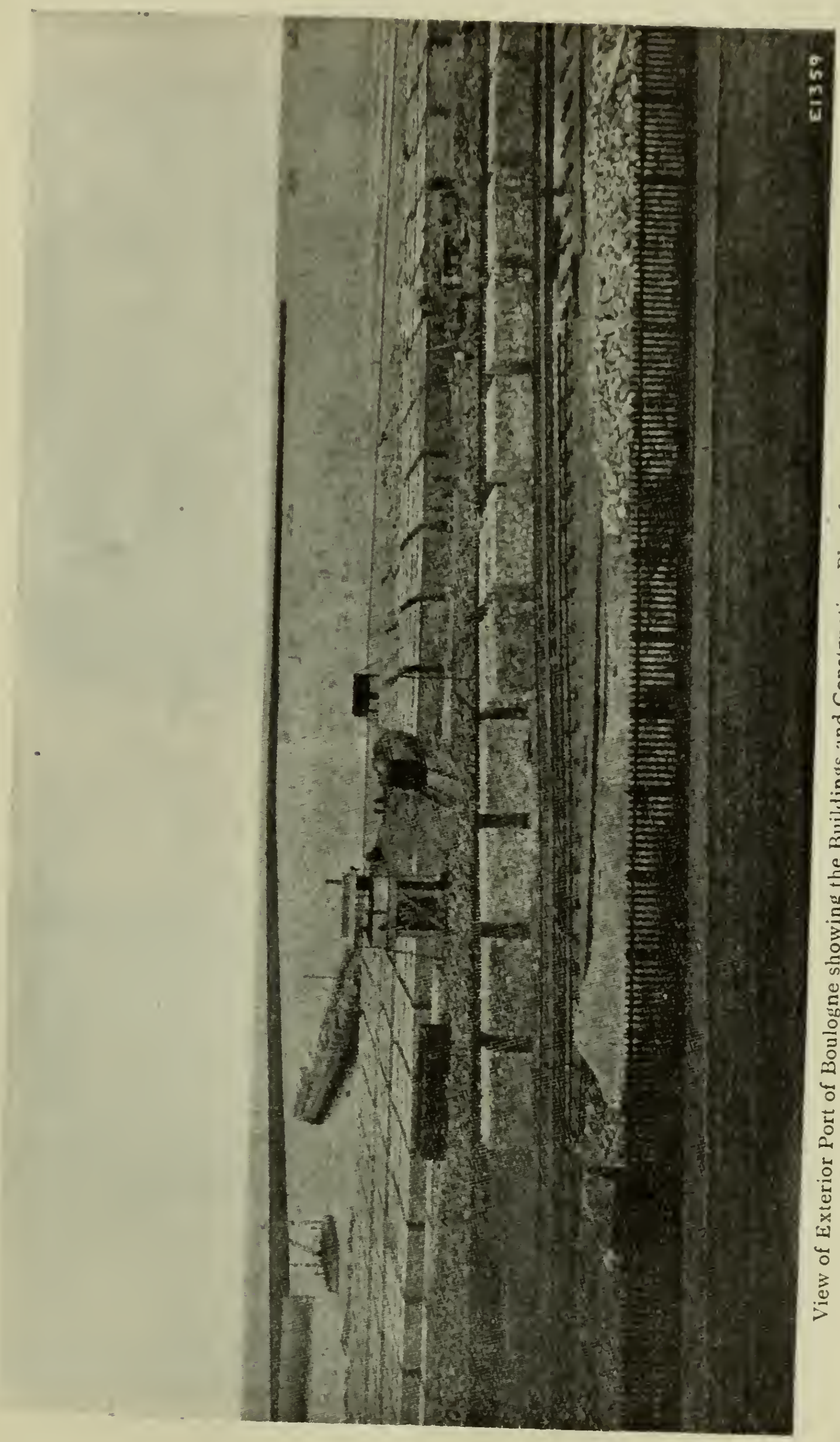
THE OUTER PORT.

The outer port comprises the Carnot Dike on the south-west, now in course of extension, two other dikes, one known as the Transverse Spur, at right angles to the Carnot Dike, and the other known as the Protective Dike, near the middle of the main sea wall. These two dikes enclose a space 233 ft. wide, forming a small harbour in which may be loaded the barges used for the extension of the port and in which fishing boats find a refuge. The large areas on which are the buildings and plant used in the construction of the harbour are on the outer port. A network of railway lines connects the harbour to the main line, a channel 1,330 ft. wide directly open to the sea, an anchorage for large vessels crossing the Atlantic situated in the shelter of the dike and deepened by dredging.

INNER HARBOUR.

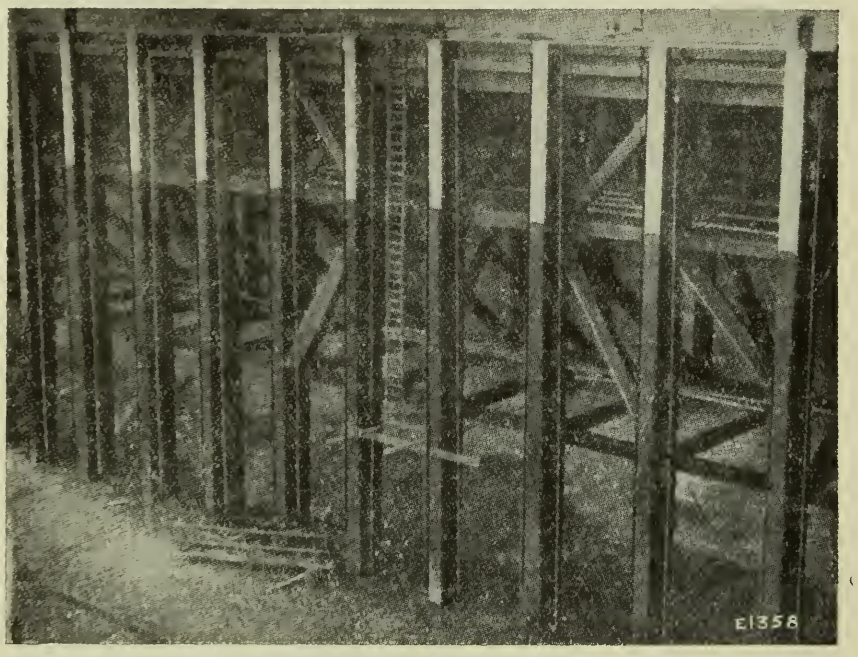
The inner harbour comprises a channel 240 ft. wide, in which there is always 17 ft. of water, a fore-port with the same depth of water and giving access to the tidal port on the north of the Chanzy Quay and containing a pier of reinforced concrete, alongside which lie the tenders which serve the liners. The tidal port is built partly of timber and partly of reinforced concrete. The rear port, including a large reservoir for the waters of the Liane, is used for a fish dock.

A floating dock communicates with the fore-port by means of a rising lock. A new portion—the Loubet Basin—measuring 1,070 ft. by 666 ft., lies between the inner channel and the fore-port and runs in an easterly direction. It comprises two walls, one at the foot of the south quay—920 ft. by 90 ft.—the other at the foot of the north quay measures 986 ft. by 90 ft. The basin is bounded on the south by a solid wall, on the west by a pier of reinforced concrete, on the north by a foundation wall surmounted by a pier of reinforced concrete, and on the east by a masonry traverse in the centre of which is a channel 220 ft. wide communicating with the fore-port. On the north-west it is protected from the prevailing winds by the Broad Dike.

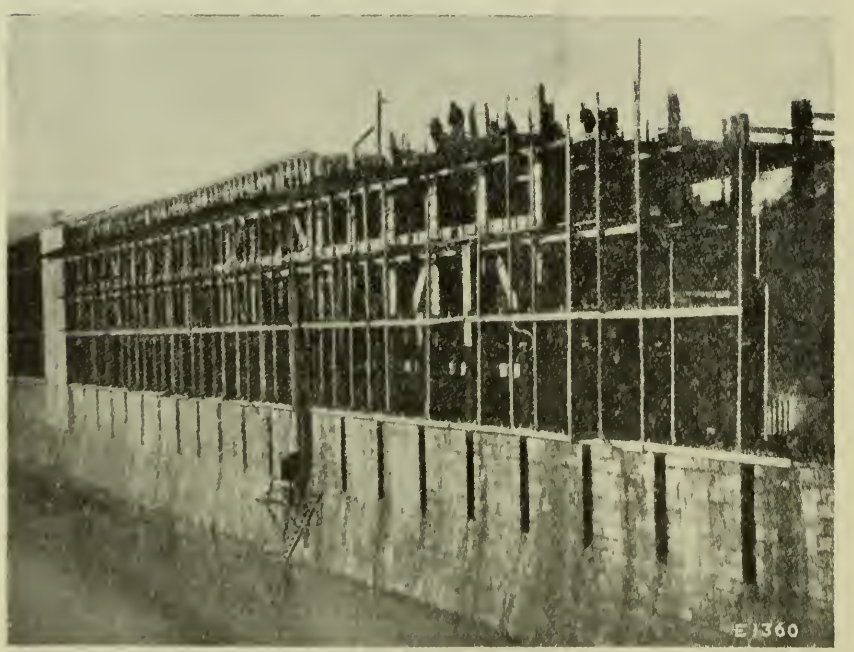


View of Exterior Port of Boulogne showing the Buildings and Construction Plant for the extension of the Carnot Dyke.

The larger side of the new fore-port opens to the north-east on the channel of the old fore-port and is bounded on the south and north-west by breakwaters forming inclined planes for the slipways, and on the west by the traverse of the basin. The Broad Dike lies between the deep water traverse and the south-west jetty at a distance of 2,000 ft. This work is formed by a mass of sand enclosed on the water side by a masonry water-wing supported on masonry and rising to a height of 20 ft. above the highest equinoctial water-mark. This water-wing is surmounted by a concrete casing. The remainder of the surface of the dike is covered with puddle. The sides of the dike are smoothed. Its width at the top is 33 ft., which is increased to 130 ft. at the middle with a view to the formation of a battery on one side.



View of West Pier during construction.



View of Foundation Wall and North Jetty during construction.

The base of clay has a uniform slope of 1 in 3. The water-wing has the same slope as the side, to which is attached a bank forming a circular road 23 ft. wide ; below this side it has a slope of 5 : 4, except at the top, where it is curved.

The foot of the dike is protected by a facing of stones 30—40 ft. wide, and also by a line of piles and sheet-piling. A roadway 27 ft. wide runs over the whole length of the dike and gives access to the shore at each end by means of masonry ramps also 27 ft. wide.

The circular road on the sea side connects the dike with the roadway which runs along the base on that side of the basin.

A ramp 17 ft. wide gives access to the upper part of the dike at the part where the latter is 133 ft. wide. Four stairways connect the circular roadway to the shore. The foundation of the wall of the south quay towards the west of calcareous clay, sand, and of sandy mud, and a sloping bed of plastic clay on the east. This wall is built on a concrete footing supported on the beechwood piles of 1 ft. in diameter arranged to form piles 3 ft. square. These piles are immersed to a depth of 16 ft. in the clayey part of the basin and 16—56 ft. in the sandy part, so as to be fixed in the adjacent clay. The concrete footing, the top of which, with an incline of 7½ per cent. from front to back to prevent slipping, is 45 ft. wide, whilst its thickness varies from 83 ft. in the front to 117 ft. at the rear. It is protected by a mass of piles and sheet-piling.

The wall is 60 ft. high and 35 ft. wide at the base, the paved front facing has an inclination of 1 in 5 to 1 in 7. In order that the basin might be extended westward at some future time, the western wall originally planned was replaced by a masonry water-wing surmounted by a pier of reinforced concrete. This structure is 666 ft. long, 66 ft. wide, and is supported by four rows of piles 16 in. square of reinforced concrete (Considère system), except those on the land side, which are only 12 in. square. These piles are surmounted by a coating of reinforced concrete made to resist the wind in every way by means of horizontal ties and braces. The pavement, which is 8 in. thick, is carried on beams each 22 in. by 14 in. and joists each 20 in. by 10 in. on the right of the metalled roads and crane-tracks. Expansion joints occur at intervals of 200 ft. The reinforced piles are 33—40 ft. long; they have been driven into solid ground by a pile-driver weighing 3 tons.

The top of the pier is covered with a pavement, the upper part of which is 20 in. above the one just mentioned; the metalled roads rest on the cross-beams similar to those on the crane track. The reinforced piles forming the first row are protected from shocks of blows by means of wooden stakes. The ground behind the pier is maintained by a masonry water-wing with a slope of 1 : 1 and 5 ft. wide. The foot of this water-wing is protected by a stout line of piles and sheet-piling. A foundation wall which supports a masonry water-wing and is surmounted by a pier of reinforced concrete built on the north side is better than the arrangement on the west side because the wing portion, particularly in the tidal basin. requires to be repaired frequently and is completely above low water level. This is 1,070 ft. long and 49 ft. wide, and is built in a similar manner to the western quay. The two first rows of piles are enclosed in a foundation wall; the reinforced piles are 46 to 58 ft. long.

The foundation wall rests, like the south wall, on a concrete foundation supported on piles 23—56 ft. long. The top of the concrete mass has 6½ per cent. slope from front to back, is 26 ft. wide and 4 ft. thick at the front and 6 ft. at the back. It is protected by a line of piles and sheet piling. The wall is 16 ft. thick at the base with an offset of 5 ft. in front and 2 ft. 6 in. at the back. The lower part of its face has a slope of 1 in 6, but the upper part is vertical. The masonry piles surmount it and afford a particularly strong protection.

The traverse is in two parts, with a space of 220 ft. between them. The one on the north, 180 ft. in length, consists of a wall with a double facing, 10 ft. wide between the parapets and connected by water-wings with the north breakwater, It is reserved for service boats. The south branch, 270 ft. by 170 ft., is built in the same manner as the south wall, and joined to the south breakwater by means of water-wings. To facilitate the movement of the vessels between the two sides of the basin, there is a stairway in each branch of the traverse on the side of the front port. The cast iron mooring posts on the quays are regularly spaced at intervals of 60 ft. The steps of galvanised iron are 120 ft. apart.

The breakwaters are inclined planes without any facing, in the upper part of which are naval ship-ways. That on the south is 722 ft. long and has an inclination of 1 in 8 and of 1 in 3 below the other side.

The north breakwater has a length of 470 ft. and an incline of 1 in 8 on one side and 1 in 3 on the other. The platforms, 170—420 ft. wide and having a total area of 24 acres, are occupied by metalled roads and warehouses. A network of drains is united in a single collector which discharges into deep water at the south-west end of the traverse and ensures the cleanliness of these platforms.

Two other piers of reinforced concrete are at the tidal port. The first is 485 ft. long and 54 ft. wide and accommodates the fishing boats and excursion steamers. The second, used by the tenders which serve the transatlantic vessels, is trapezoidal in form, its longest side being 115 ft. Both these piers are built in the same manner as the west of the Loubet Basin.

The Loubet Basin cost about £450,000.

MEMORANDUM.

Municipal Houses.—The plans for the municipal houses to be built on the Oak Tree Lane site were recently exhibited at the Birmingham Council House. The winning designs are sent by Messrs. Ingall, Bridgewater, and Porter ; and premiums have also been awarded to Messrs. Crouch, Butler, and Savage ; Mr. H. S. Scott ; and Mr. E. Berks Norris.

The plans and specifications for all the above provide for ordinary brick walling and the use of concrete for internal walls and partitions. In one case the windows are specified to have concrete frames and steel casements. The cost of building these houses is anywhere between £750 and £950.

In comparison with these figures it is interesting to note the cost quoted for the houses planned by Mr. A. J. Dunn, another Birmingham architect. These plans provide for concrete construction, and when the requirements as to room-space, thickness of walls, accommodation, and fittings of the Corporation and the Ministry of Health have been complied with the architect estimates that he can build these houses at an average cost of £552. If brick construction is adopted the cost would come out at £772, a considerable saving on most of the other plans, which is due to the fact that certain dressings used would be of concrete even though bricks were the material mainly favoured. If the concrete building were adopted all the floors would be of that material. The various pieces would be cast away from the site and be brought there ready for erection, the joints being made of cement. An almost infinite variety of design could, it is claimed, be obtained, the houses would take much less time to erect, and a very considerable saving would be effected in the cost.

REINFORCED CONCRETE FLOOR TESTED WITH A MILLION POUNDS OF PIG IRON.

By ROBERT H. MOULTON.
Board of Trade, Chicago.

There are various features in connection with the floor test here described which are of particular interest.—ED.

SUBJECTING the floor of a modern structure of concrete with steel reinforcement to the weight of a million and a quarter pounds of pig iron in order to determine what scientists call the "point of destruction," was the remarkable test carried on in Chicago by Professor A. N. Talbot, of the University of Illinois. According to Professor Talbot, this is the first instance on record where such a test has been made on a building which had not been especially constructed for a test, and which had been in service for a number of years.

The opportunity to make the test came about as the result of the wrecking of a large number of buildings to make way for Chicago's new Union Station. Among these buildings was that of the Western Newspaper Union, a reinforced concrete structure erected in 1909 at a cost of $175,000. The plan dimensions were about 107 ft. by 120 ft. The Western Newspaper Company used the building for heavy printing machinery and the storage of paper stock, hence the designing live-loads were large, being 300 lb. for the third, fourth and fifth floors and 250 lb. for all others. The lower five floors and the top floor were beam and slab construction, while the sixth and seventh were flat slabs without beams.

Because the funds available were limited only one test could be made, and for this purpose four interior panels of the sixth floor were selected. These panels were 17 ft. 5½ in. by 4½ in. between column centres. The design called for an 8½ in. slab, reinforced four ways with the direct and diagonal bonds 7 ft. wide, each carrying fifteen ⅝ in. round rods. The width of the octagonal column caps was 4 ft. 6 in. The short diameter was 24 in. for the columns of the fifth floor and 21 in. for those of the sixth floor, while the column cores were 21 in. and 18 in. respectively. At all columns the outer ring of the spider was a ¼ in. round, 8 ft. 6 in. in diameter; the inner ring a 1 in. round, 4 ft. 6 in. in diameter. The column longitudinal reinforcement consisted of eight 1½ in. rounds, bent out radially at the floors and running beneath the spider rings. The hooping of ⅜ in. rounds had a pitch of 2½ in. Tests of reinforced rod specimens taken from various parts of the building proved the material to be a high carbon steel instead of the mild steel ordinarily used for reinforcement. These specimens gave a yield point of 65,000 lb. per sq. in. and an ultimate strength of about 100,000 lb. per sq. in. A concrete with pebble aggregate of 1:2:4 mixture was used in the slabs, and of 1:1:2 mixture in the columns.

In preparation for the test 200 gauge lines on the steel and the concrete and deflection points were arranged with a view to ascertaining the strains in the materials in critical places and the action of the slab under load. After taking preliminary measurements the panels were loaded with pig iron, and after each increment of load, amounting to 200 lb. per sq. ft., had been placed, observations were made at all gauge lines and deflection points. Care was taken in placing the pig iron to eliminate the possibility of any arching action in the material itself. When the load of pig iron reached about 340 lb. per sq. ft., the maximum deflection at the centre of the panels was ·33 of an in., the maximum stresses in the steel, 23,000 lb. per sq. in., and in the concrete about 1,500 lb. per sq. in. Loading was continued until 1,232,000 lb. of the pig iron was on the four slabs.

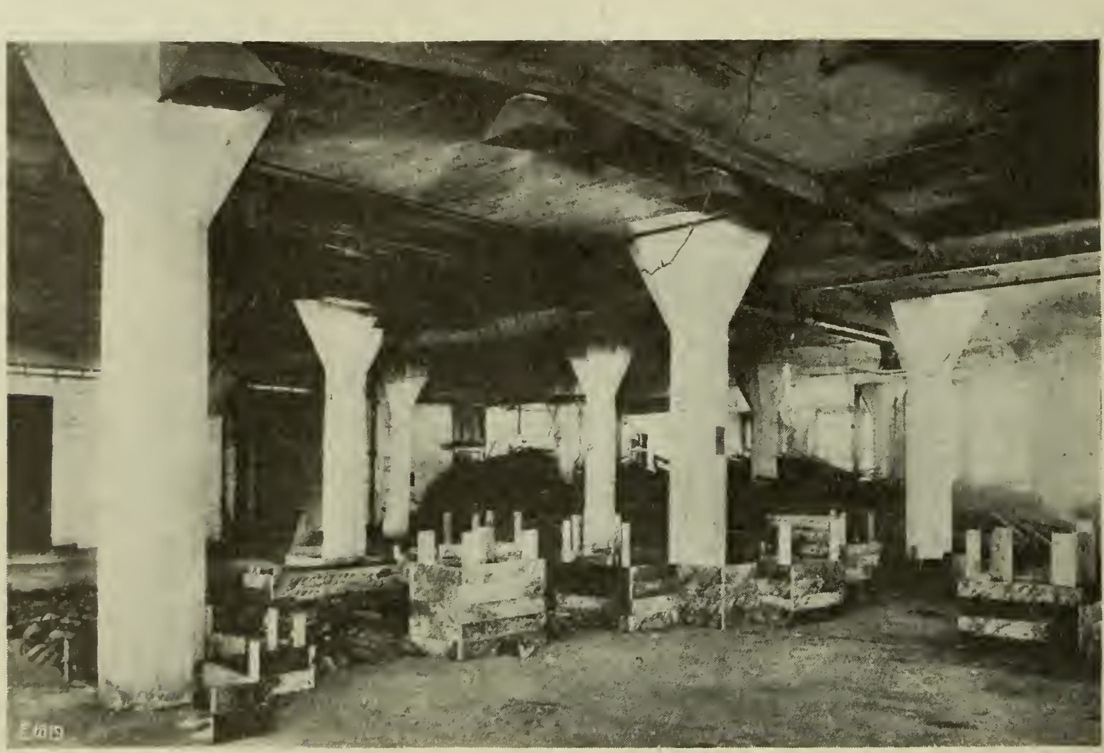


Fig. 1. Test Panels ready for loading. Forms for observation purposes in place.

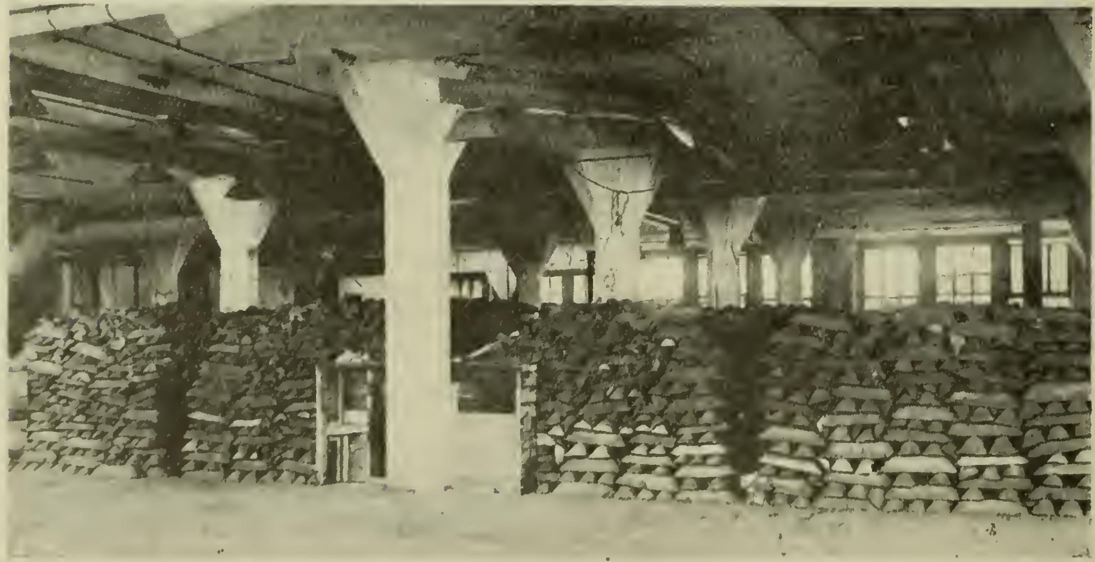


Fig. 2. Final load of 910 lbs. of pig iron per sq. ft. in place.

which is the equivalent of 910 lb. per sq. ft. Adding to this the weight of the slab gave 1,015 lb. per sq. ft. for the total load. The superimposed load was 3·64 times the designing live-load and the total load was 2·9 the designing total load. The maximum deflection produced was 1·1 in. Preliminary computations gave the following as the indicated average stresses in the steel:—

At the centre column, diagonal rods, 52,000 lb. per sq. in.
At the centre column, direct rods, 31,000 lb. per sq. in.
At centre of panels, diagonal rods, 18,400 lb. per sq. in.
At centre of panels, direct rods, 23,800 lb. per sq. in.

The compressive strains in the concrete at the bottom of the slabs at the centre column were in the neighbourhood of ·0012 to ·0015. Inasmuch as laboratory tests have not yet been made on the concrete specimens taken from the building, the stress corresponding to this strain is not known, but this deformation is that of concrete at about its ultimate strength per in. Spalling of the concrete around the column capitols substantiates the belief that the concrete had reached its ultimate strength. In view of the results of previous tests on reinforced concrete columns, it can be stated that none of the columns were greatly stressed, the centre column, which naturally carried most of the load, being stressed only to, about one-fourth of its ultimate strength. A few days after this point of incipient failure the load was removed and measurements again taken. The permanent deflection was approximately ·35 of an in. The location of the largest unit radial

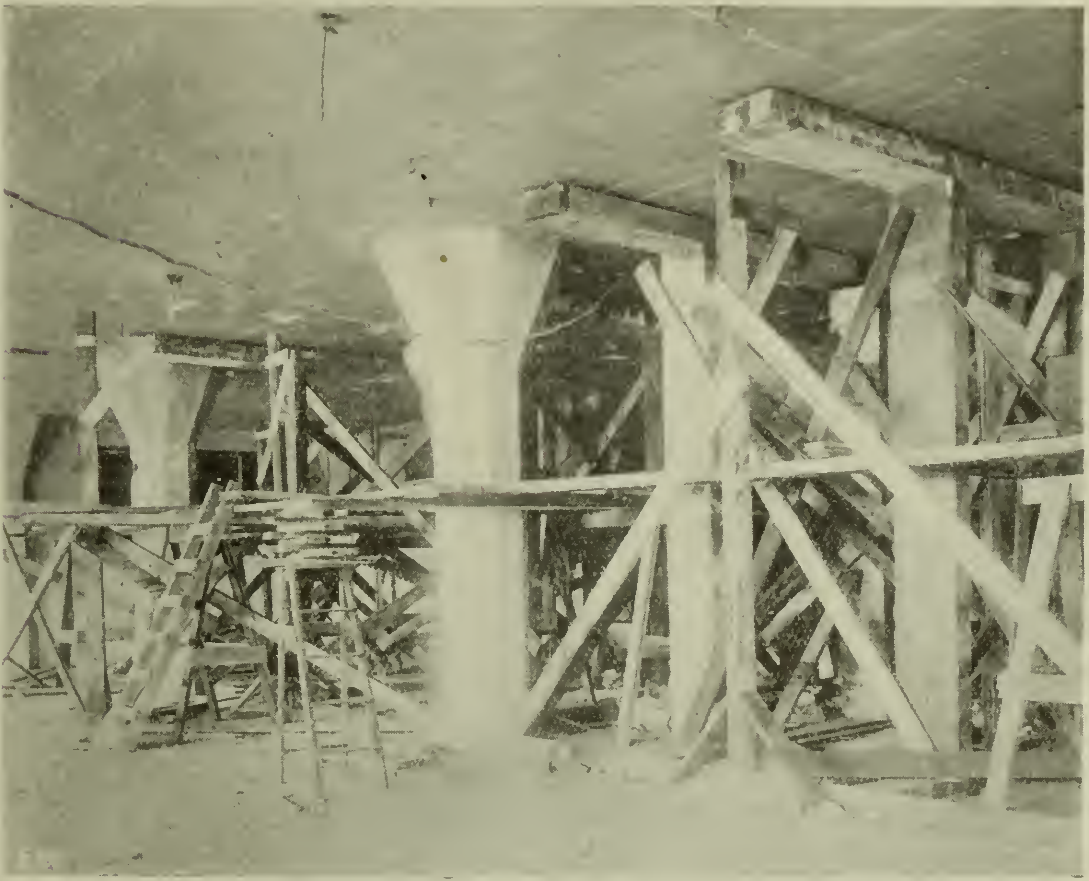


Fig. 3. Platform beneath loaded floor to facilitate gauge and deflection readings. Bracing shown was intended to catch floor in case of complete failure.

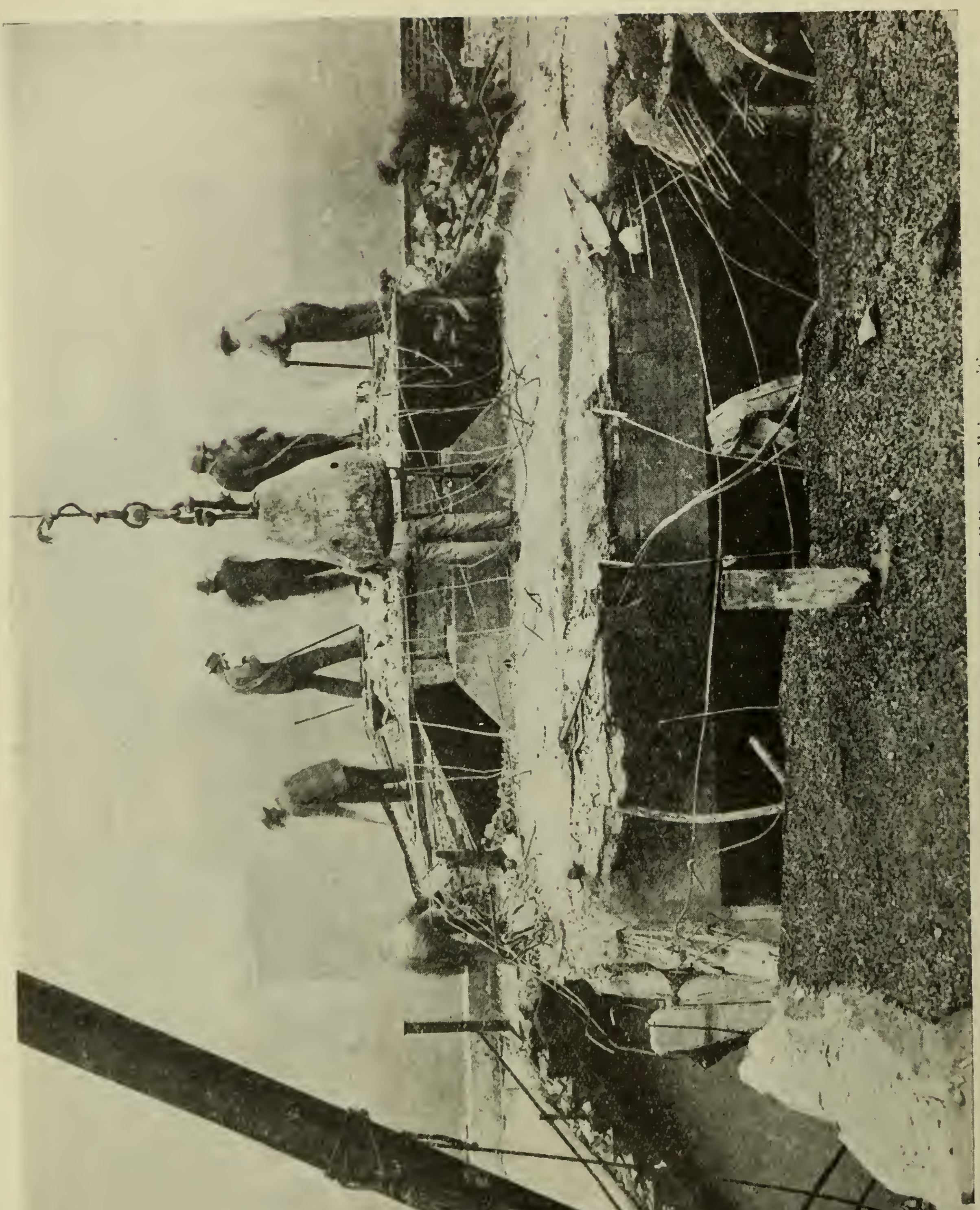


Fig. 4. 1,200 lb. iron ball used to demolish a reinforced concrete building. Ball in position ready to be dropped showing result of pounding in background.

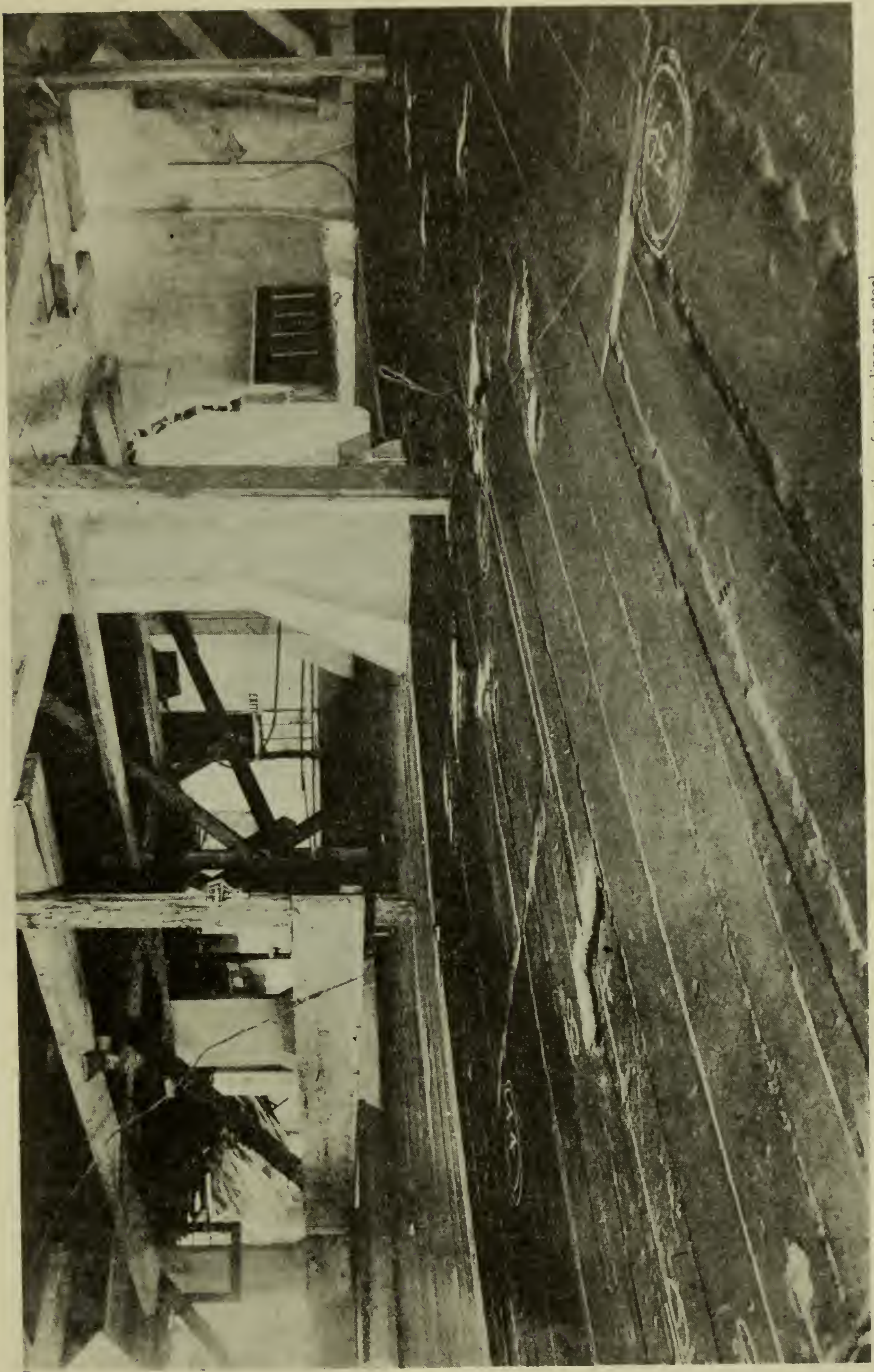


Fig. 5. Underside of tested floor, showing concrete removed to allow insertion of gauge lines on steel.

stress in the concrete was clearly disclosed by cracks in the slab following the perimeter of the capitols underneath more or less closely. Cracks also developed in the bottom of the slabs at the centre of the panels and in the top of the slabs along the lines indicating the edges of the panels. All of these cracks followed those lines where they were expected to appear.

The value of the test consists not merely in showing the strength of these slabs, but also in showing how the stresses are distributed throughout the floor and what proportion of the load is taken by the various systems of reinforcement. However, the fact that only four panels were loaded limits the value of the data in its bearing upon moment coefficients for use in design. In the opinion of some engineers the test indicates that too great a factor of safety is used in reinforced concrete design, while others are convinced it justifies present standards and advance several reasonable arguments to support their views. For instance, when the slabs were broken up after the test, the concrete in three of the panels was found to be quite hard, while that in the fourth was broken with comparative ease, showing that with the present practices of mixing and placing, concrete cannot be made a homogeneous material such as steel. Then, too, the reinforcing bars in the tested floor had a strength greatly in excess of that ordinarily used. Another point overlooked by many discussing the investigation was the fact that the bars were overlapped at the columns to such an extent that more steel than that indicated by the design was useful to resist the stresses at that point, where they are known to be greater than at other parts of the floor system. An investi-

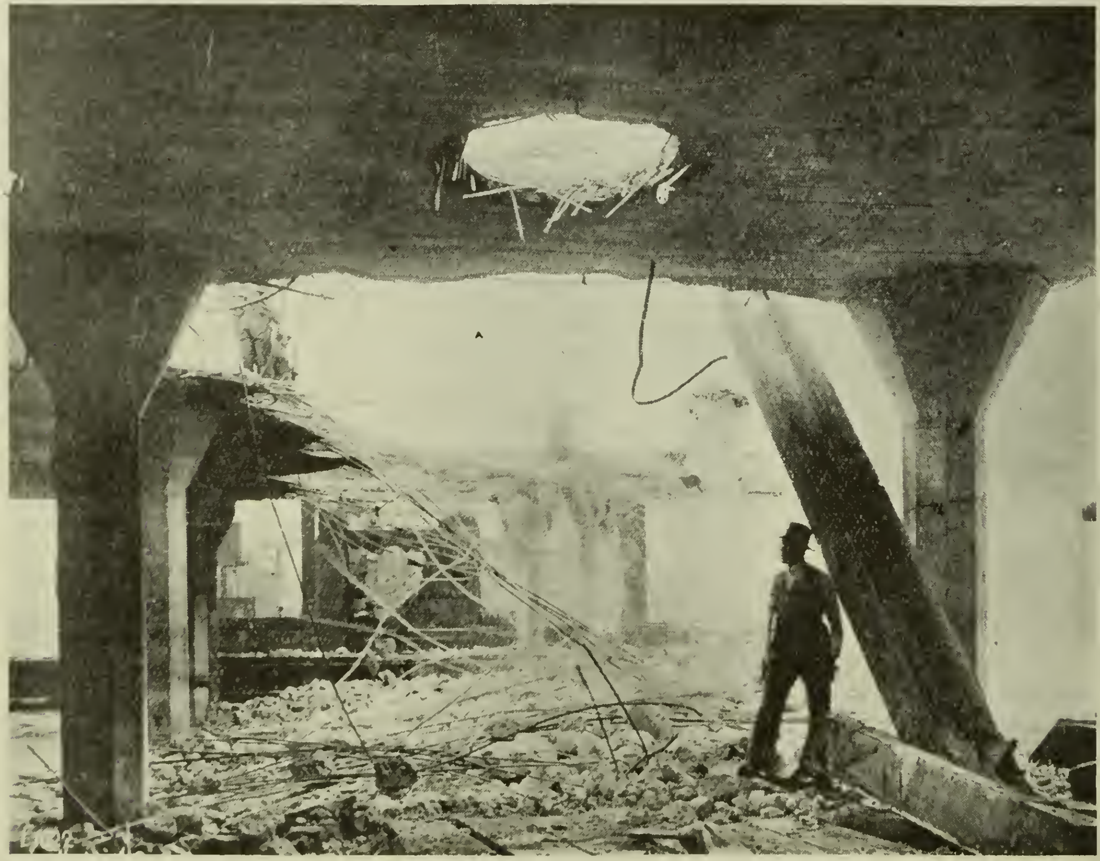


Fig. 6. Chute through floor to permit lowering of material.

gation of the design of the floor, based upon a ruling on flat slabs made in 1914 by the Chicago Building Commissioner, showed that the tested slabs contained about twice the amount of reinforcing than would have been required by the ruling. This investigation of the design did not take into consideration the fact that the rods, after overlapping at the columns to secure continuity of their action, extended beyond about one-third of the span between columns. In other words, had the design of tested slabs been based upon this 1914 ruling and had the overlapping of the rods and the quality of the steel been in conformity with usual reinforced concrete standards, it is quite evident that the floor would not have been able to sustain so great a load as was placed upon it in this test.

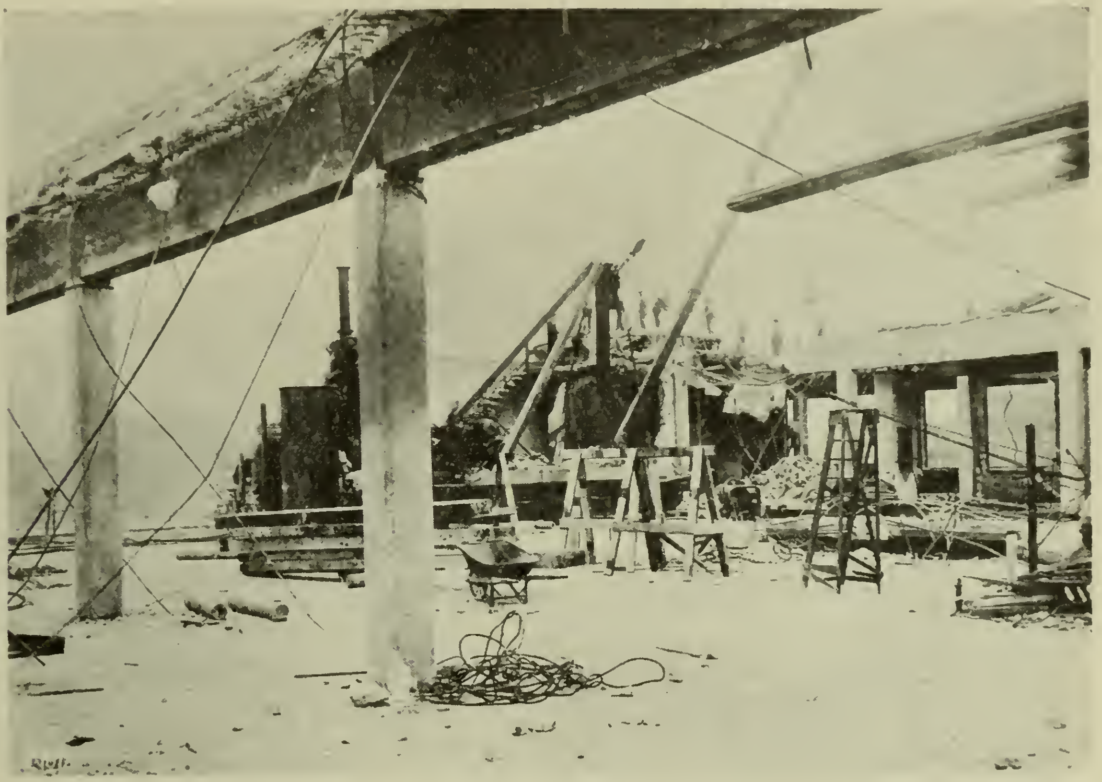


Fig. 7. One floor almost demolished.

Another interesting experiment in connection with the building on which the above test was made came about later when the actual razing of the structure was begun. In order to facilitate the work, as well as to economise in the amount of labour required to demolish the building, the wrecking concern conceived the unique idea of using an iron ball weighing over half a ton. A wrecking outfit that would operate between the columns of the building was constructed, and consisted of a stiff-leg derrick and 40-ft. boom, mounted on a 16 by 24 platform with rollers, the ball, or "skull-crusher," as it was called, being carried on a single fall line. A 25 h.p. direct current electric hoist furnished the power for hoisting and swinging. The job of hoisting the various parts to the roof of the building and assembling them was a difficult one, several days being required for the work.

The method employed in using the ball was to drop it through a distance of approximately 40 ft. on the central parts of a slab. This had the effect of shattering the concrete up to the column capitols or to the edges of the beams. The reinforcing bars were then cut by means of an oxy-acetylene torch. The ball was next directed over the centre of the column, the blows in this instance resulting in breaking the concrete away from the rods at the base of the columns on the next floor to a height of 4 ft. or 5 ft. As much of the column concrete as possible was broken off in this way, after which a fire was maintained around the column base for a number of hours and then water thrown on the column. This operation caused the concrete to crack and weakened the column. Then when the reinforcement had been cut with the oxy-acetylene flame, it was an easy matter to pull the standing mass over with a block and tackle attached to the electric hoist. The beams, of course, were brought down with the columns, and the ball was also used to break up pieces of concrete too large to be loaded for hauling away. The brick walls not backed by concrete were easily knocked over by swinging the ball against them.

Of a force of 65 men employed in wrecking the building, only four were required to operate the iron ball. Ten weeks were required to raze the building, the work proceeding at the rate of a floor a week, with two weeks for the heavier construction of the basement. The total cost of demolishing the building, without taking into consideration the question of salvage, was approximately $20,000, or about 15 per cent. of the original cost of the building. This compares with 10 per cent. on the wrecking of other reinforced concrete buildings, the difference being due to the present high cost of labour.

A CONCRETE ROAD IN HENNEPIN COUNTY, MINN., U.S.A.

THE FOREIGN PRESS.

Caissons of Reinforced Concrete in Italy.—The bridge constructed over the Crate connecting the residential part of Rose with the Libari-Cozeza railway and the National Calabrian railway is 1,170 ft. in length, 40 ft. in width. It is divided into four parts and is calculated to carry a load of 130 lb. per sq. in. The chief feature of the bridge are the caissons of reinforced concrete which are in the form of an inverted rectangular tank with sloping interior sides and vertical exterior ones, the reinforcement being of three kinds: (*a*) stout bars conforming to the interior of the caisson; (*b*) lighter rods placed near the exterior, and (*c*) still lighter ties uniting the other reinforcement.

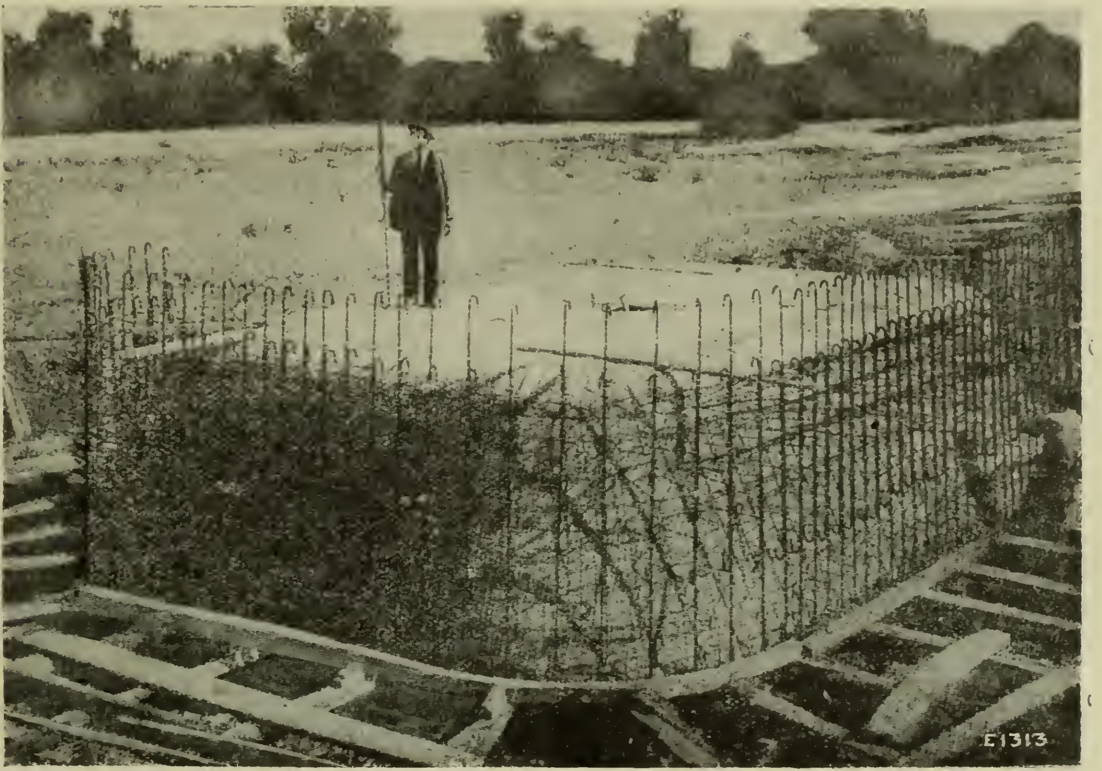


Fig. 3. Showing Reinforcement of Caissons.

The greater part of the concrete consists of a mixture of Portland cement, sand and gravel in the proportions 2 : 3 : 6, but the exterior was finished with a grouting composed of one ton of Portland cement to 1,000 cb. yds. of fine washed sand.

The advantages of caissons of reinforced concrete as compared with those of metal are greater freedom of design ensuring greater stability, reduction in the amount of costly material, more massive construction for the same cost, the smaller number of highly skilled workmen required, and a considerable reduction in maintenance.—*Annali d'ingegneria e d'Architettura.*

Quay Walls of Reinforced Concrete in Various Ports in the Dutch Indies.—According to a paper read by Mr. W. Cool before the Royal Institute of Engineers at Semarang, most of the ports of Sumatra owe their importance to their situation at the mouth of a navigable river, though the latter cannot always be reached in dry seasons on account of bars of sand which occur near the mouths. This has led to the construction of ports which are quite distinct from the river mouths. Unfortunately the extensive works which have been executed have been accompanied by very serious difficulties, owing to the uncertain nature of the natural foundations around the coasts of these islands.

At the Port of Soerabaja in Java the depth of the channel increased from 14 ft. in 1907 to 21 ft. in 1918. At high tide the water rises 6 ft. and vessels with a draught of 21 ft. can enter or leave at any time. A depth of 28 ft. below sea level occurs over an area of 333 sq. yds. in the least favourable part of the port. In 1911, a Dutch firm undertook to execute the requisite harbour work for £1,176,400, including the construction of a flat area 220 yds. wide on the west of the Kali Mas, and restricted on three sides by sunken walls (built on caissons) at a depth of 44 ft. below sea level, and rising to 3 ft. below the surface. The caissons were similar to those used at Rotterdam, and were 40 ft. high by 130 ft. by 40 ft., each being divided into 30 chambers. The bottom is 10 in. thick and the sides 8 in. The concrete consisted of Portland cement and sand and stone in the proportion of 2 : 3 : 4, the chambers nearest the water being filled with a mixture of 1½ parts of Portland cement, ½ part of trass, 3 parts of sand, and 5 parts of crushed stone. The other chambers were filled with sand. The superstructure consisted of a concrete wall 5 ft. thick, of cement and sand and stone, in the proportion of 1 : 2 : 4. No special incidents were reported during the progress of the work, but the western portion fell suddenly into the entrance to the port on May 3rd, 1916, without giving any warning except a few cracks in the adjacent ground.

No lives were lost, but three caissons and their superstructure slipped forward and fell, so that the top of the caissons was immersed in the water. It has since been found that the bed of sand on which they were built was contaminated with a stratum of ferruginous mud about 3 ft. thick, which was loosened gradually by the water and so was the cause of the accident. The quay was repaired by constructing three shields of reinforced concrete surrounding the caissons, removing the superstructure from the latter by blasting, withdrawing the sand by suction and raising the caissons to their former position. All three caissons were restored within nine months after the accident and stronger foundations provided at a cost of £47,800.

An extension of the coal quay on the southern side of the same harbour was effected by means of a series of caissons 43 ft. high, with a mass of sacks filled with cement, placed so as to form a buttress 30 ft. wide at the base on the land side of each caisson. The wall thus produced cost £23 per sq. yd.

At the Port of Pirogues in Semarang a series of movements in the quay-structure observed in 1913 also showed the necessity of preparing the foundations with sufficient care. The reinforced concrete caissons used at this port were built on a bed 42 ft. wide at a depth of 20 ft. below sea level, the work being commenced in January, 1913. The preparation of the bed was regarded as satisfactory, but movements were observed during the filling with sand. This work was continued until midday of March 10th, 1914, when four caissons began to slip, a strip of sand 4 ft. wide sank to a depth of 5 ft., and cracks up to 73 ft. long appeared in the ground at the rear, the depth of the port being reduced by 5 ft. The movement ceased the next day, and the damage was repaired by erecting two walls of stonework, one in front of the foot and the other behind the base of the caissons, together with an embankment behind the quay wall. A further subsidence occurred in November, 1915, and it was then decided that another mode of construction was essential. This consisted in preparing a much larger foundation of sand, but this did not prove sufficiently stable, and a third attempt was made in which large pieces of coral rock were placed on the sand bed so as to keep it in position. So far this appears to be successful for present requirements, but it would not be safe to use this quay for excessively heavy loads, and there is always some uncertainty as to its safety.

At the Port of Macassar in Celebes the caissons have been protected by a mass of rocks placed on the land side, but even here a slipping of about 1 ft. occurred and several minor movements have been observed. Such a mass of rocks is usually preferable to sand on an uncertain foundation as it has less specific gravity and a high coefficient of friction which greatly reduce the tendency to slip horizontally.

It is noteworthy that in none of these works has the effect of the seawater on the concrete been appreciable.—*De Ingenieur.*

Calcium Aluminium Sulphate as a Destroyer of Concrete. Calcium aluminium sulphate is formed when a concrete contains free lime, alumina and any soluble sulphate, but may be produced by adding a solution of aluminium sulphate to lime water. When it is produced by the action of a sulphate on cement the highly hydrated crystals rapidly fill the pores and frequently cause the concrete to crack. If free lime and alumina are removed or rendered inert the double sulphate cannot be formed and a stronger concrete is produced.

The action of calcium aluminium sulphate on concrete was compared by Michaelis to that of bacilli on animal organisms and consequently it received the name of *cement bacillus*, but this is only a whimsical term, and so misleading that it should be abandoned.

The crystals are only stable in the presence on water almost saturated with lime. Pure water decomposes them, dissolving the lime and calcium sulphate produced, and leaving the alumina as a white floculent residue. The crystals are still more rapidly dissociated by solutions of salts or acids, and by sea water, and sea water appears to prevent the formation of the crystals in concrete.

H. Nitzsche has recently suggested that the probability or otherwise of a concrete being damaged by the formation of these crystals may readily be tested by treating a cement or powdered concrete with a sulphate solution or with water suspected to contain ingredients which may cause the formation of the double salt. The relative harmfulness of the cement, aggregate, water or solution is judged by comparing the crystals produced during a week when it and various standard solutions are added to a standard cement. No crystals of the double salt were produced in a long series of such tests using either natural or artificial sea water, nor were they found in test mortars which had been immersed for a prolonged period in sea water. Consequently, the destructive action of sea water on concrete must be referred to other causes, and not to the sulphates present.

The destruction of concrete by limited quantities of ground-moor or drain water, sewage or sulphate solutions may be attributed to the formation of the double salt and such fluids should therefore be kept away from concrete structures. Crystals of calcium aluminium sulphate have also been found in many samples of concrete and mortar taken from structures exposed to the action of sulphate solutions, these crystals being readily observed if a small piece of the dry material is broken and examined under a microscope having a magnification of 50 to 100 diameters. The crystals are not formed in decomposed or weathered material, but only in that which has not been unduly exposed to the weather or water. The existence of a white aluminous film is an indication of the conditions being unfavourable to the existence of crystals of the double salt.

In cements, concretes, and mortars which are exposed to large quantities of water the crystals cannot be formed, as the quantity of water would make the lime solution too dilute. On the other hand, a very dilute solution of a sulphate will, in time, destroy a structure exposed to it, if sufficient lime is present in the cement or mortar to prevent the dissociation of the crystals.

The best means of preventing the destructive action of the double salt are of two kinds :—(i) By the use of concrete of such a nature that the harmful fluids cannot penetrate it, and (ii) by the use of resistant materials in the concrete. The first method consists chiefly in closing the pores of the concrete by exposure to carbonic gases, so as to effect the carbonation of the free lime in the material, or by the addition of magnesium chloride, which forms finely divided magnesium hydrate which fills the pores of the structure. The concrete may be also made waterproof by suitable agents, or by coating it with bitumen, asphalt, or tar, though such coatings are usually too costly. The second method consists in using cement which does not contain the compounds required to form the crystals, such as the substitution of cement containing iron oxide in place of the alumina in Portland cement, or in the use of slag cements low in lime ; the latter is at present one of the most certain preventives. Alternatively, material may be added such as puzzolana, trass, brick dust, granulated slag, santorin earth, etc., which can combine readily with the lime set free by the action of water on the Portland cement. Such materials reduce the porosity of the cement, but their chief action is in converting the lime into a compound which cannot at all take part in the formation of the double crystals. Unfortunately, the reaction between the lime in the cement and the silica in the added material is so very slow that such materials do not invariably prevent the formation of the crystals. (From *Beton u. Eisen.*)

Reinforced Concrete for Structures Exposed to Sea Water.—The Society of German Portland Cement Manufacturers, in collaboration with the Material Testing Bureau at Lichterfelde and the Hydraulic Works Inspection Department at Husum, on the island of Sylt, have been experimenting for about 20 years in order to discover the most suitable mixture for concrete for sea-water structures. In this connection Dr. Gary has recently published a detailed report in a communication of the Material Testing Bureau, of which the conclusions are as follows :—

In order to obtain suitably strong structures in sea water, it is necessary to use cement which is as rich as possible in silicates, but poor in kaolin and iron oxide. Such cements, when at the same time they are rich in lime, can be considerably increased in value by adding certain quantities of trass. The decisive factor, however, for the permanence of concrete structures in the sea is the use of mixtures which are as dense as possible and impervious to sea water, while at the same time sufficient external hardening should be given to the substances before they are placed in the sea by exposing them to heat and to moist air. Concrete, the mortar of which contains more than 66⅔ per cent. of sand, will generally not show the necessary density to enable it to stand attacks by sea water for any length of time. (*Mitteilungen des Reichsbundes Deutscher Technik*, No. 30, 1919.) *Technical Review.*

INDUSTRIAL NOTES.

These pages have been reserved for the presentation of articles and notes on proprietary materials or systems of construction put forward by firms interested in their application. With the advent of methods of construction requiring considerable skill in design and supervision, many firms nowadays command the services of specialists whose views merit most careful attention. In these columns such views will often be presented in favour of different specialities. They must be read as ex parte statements—with which this journal is in no way associated, either for or against—but we would commend them to our readers as arguments by parties who are as a rule thoroughly conversant with the particular industry with which they are associated.—ED.

A RECENT DEVELOPMENT IN REINFORCED CONCRETE.

In estimating the requisite amount of reinforcement required in a reinforced concrete road, resting on an earthwork foundation, assumption must be made as follow :—

(*a*) The bearing capacity of the road bed.

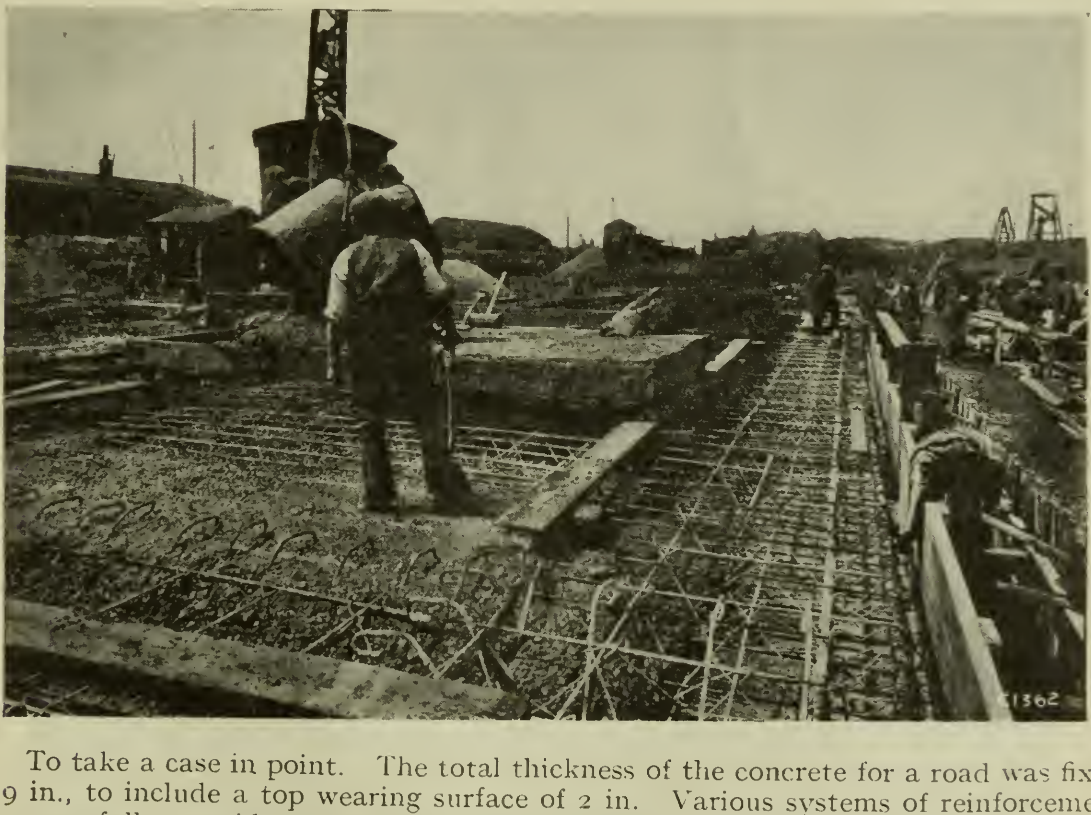
(*b*) The maximum wheel loads, the gauge of the wheels, and the distance apart between the axles.

(*c*) The allowance for impact.

In endeavouring to estimate (*a*) it must be borne in mind that reinforcement is usually introduced into a concrete foundation for one or both of two purposes, viz. :—

(1) To prevent cracks due partly to the setting of the newly made concrete, and also to the changes of temperature it is subjected to.

(2) To reinforce the concrete to enable it to act as an efficient slab, to distribute the load over a sufficiently wide area of the road bed without permanent deformation or failure due to cracks.



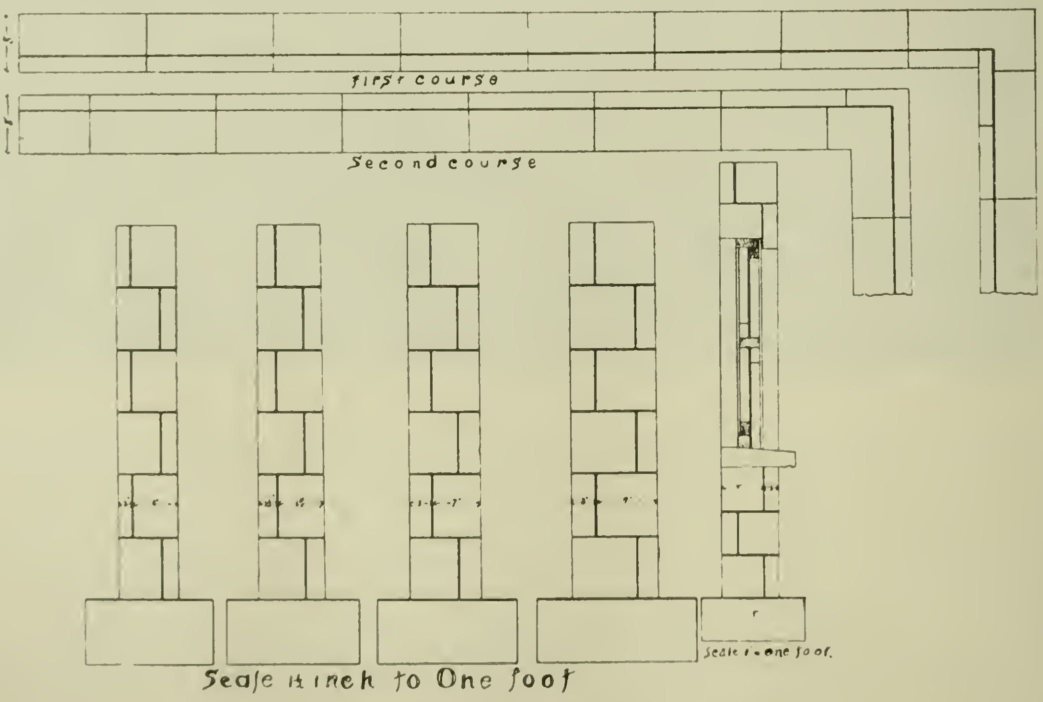
To take a case in point. The total thickness of the concrete for a road was fixed at 9 in., to include a top wearing surface of 2 in. Various systems of reinforcement were carefully considered, both as regards efficiency and economy. Previous experience in the making of a good bottom for macadam roads had shown that, with the formation covered with a layer of hardcore 9 in. to 12 in. thick, a 5-ton roller, in many places, sunk to the axles in the mud pockets. In such circumstances it was considered that the concrete must have top and bottom layers of reinforcement, to provide for the tensional contra-flexure stresses imposed by a rolling load. It was also thought necessary that these top and bottom layers should be connected together by some system of vertical reinforcement to provide for the shear or diagonal tension stresses.

Having decided upon these requirements, a system of reinforcement was designed after much thought and study and put into use. A plan of this design appeared in the January number of CONCRETE, and the figures therein illustrate the reinforcement as laid ready for concreting.

In the making of a reinforced concrete structure, such as a road or raft, it is also essential that the reinforcing bars be in their correct positions in relation to the surrounding concrete. This has been conveniently and successfully solved in the case of the system now described, which is essentially a practical one. The method employed is to have the wire and bars delivered from the rolling mills direct to the site of the road, with consequent great economy in the cost of reinforcement. The coils of wire are straightened out by means of a winch and cut into desired lengths. Benches are erected on the site for the use of the steel-benders. These benches are moved forward at convenient intervals as the road progresses. The system of interlocked reinforcement consists of top and bottom layers of reinforcement, which are interconnected by zig-zag inclined bars in the shape of pyramids, and combined with a perfect system of interlocks. The top and bottom layers reinforce the surface and foundations, and the pyramidal inclined bars act as tension or shearing members. Should the load rest on a faulty piece of ground, the wires radiating in all directions spread the load over the adjacent areas capable of supporting the weight. To this framework, when in position on the road bed, any additional bars required may be attached at desired spacings, by means of short lengths of annealed wire. The units are made in handy lengths and are easy to make, fix and lay. The reinforcement is made continuous, and no overlapping is required. No objectionable expansion joints have to be provided, and the framework has no welds which might be liable to flaws. This system of reinforcement is used extensively by the Port of London Authority on their vast schemes of construction. A brochure with illustrations and full description of this system is being issued to engineers, architects, and builders by the company established to work this patent—namely, The Walker-Weston Co., Ltd., 7, Wormwood Street, E.C.2.

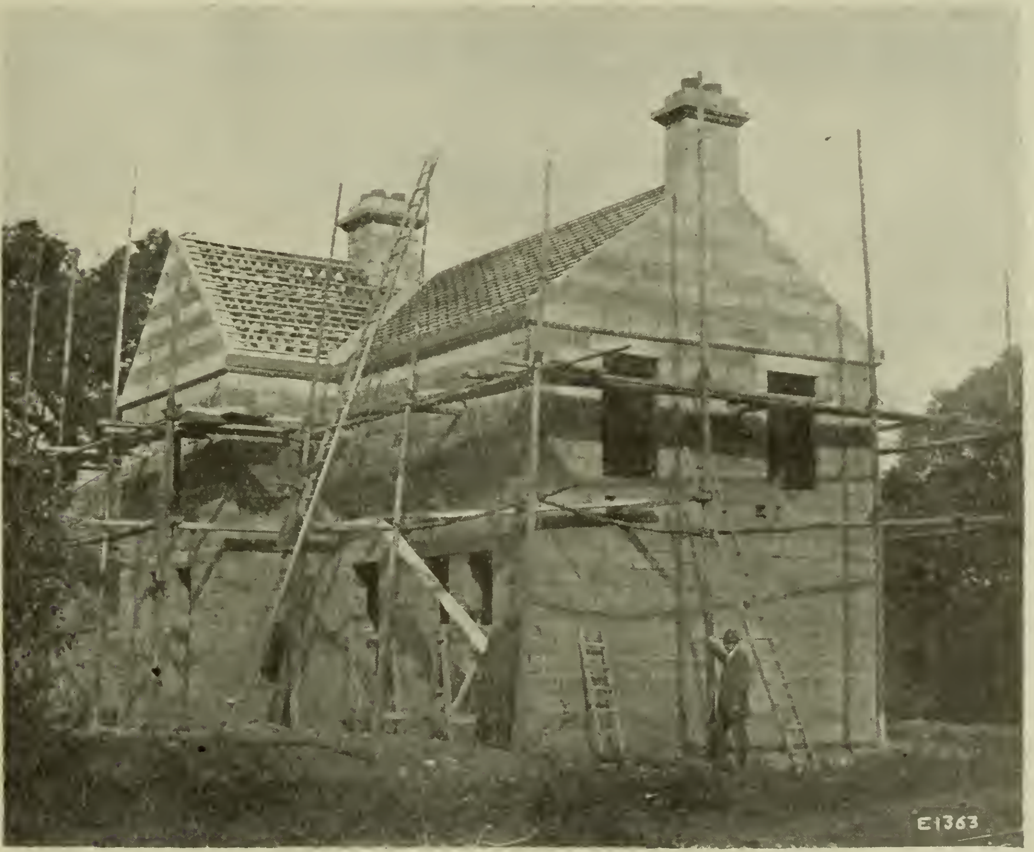
A CONCRETE BLOCK DWELLING ERECTED IN IRELAND.

OUR attention has recently been drawn to a scheme for erecting concrete block dwellings with a damp-proofing course, instead of adopting the hollow wall principle. Simplicity, efficiency and cheapness are claimed for this method, of which some particulars are given below. The system is really the old block-building system of 15 or 20 years ago plus a proper damp-proofing. Take, say, a 10 in. wall. The blocks

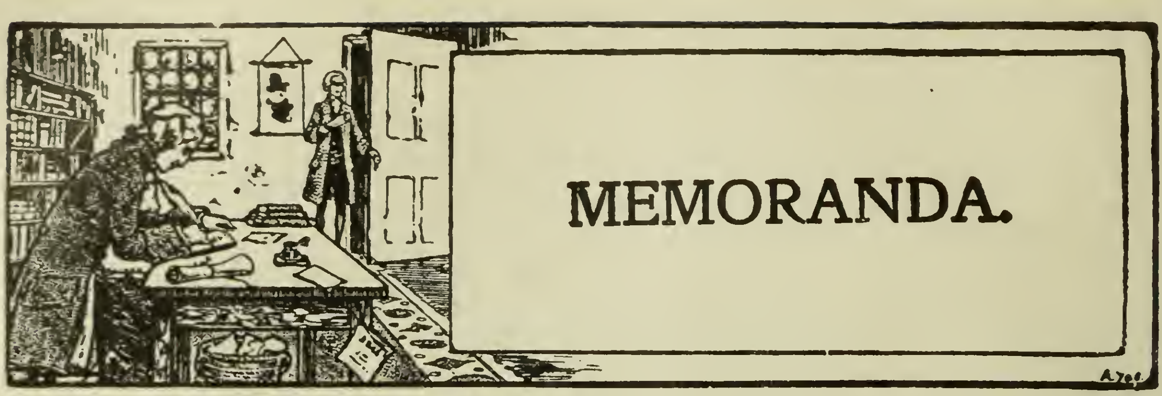


SHOWING LAYING OF BLOCKS.

in this wall are made 3 in. and 7 in. wide, and a wide block and a narrow block are laid alternately in each course, giving a 4 in. bond, as shown in the accompanying illustration. Between the joints, both vertical and horizontal, is placed a membrane of pliable double-dipped bituminous felting, which causes the inside of the house to be perfectly dry. The internal blocks are made of breeze concrete, which are absorbent and prevent condensation, and which save a great deal of carpenters' time, inasmuch as skirtings, picture mouldings, and cornices can be nailed direct to the wall. Very porous ordinary concrete will do as a substitute for breeze. We are informed that the resultant wall is a good solid wall, well capable of bearing the thrust of the roof. Not satisfied with the theoretical excellences of the system, however, the inventor built an experimental eight-room villa (shown in the accompanying illustration), which cost only £800 (which does not include cost of land or sanitary conveniences), and the entire walls of which were erected by two masons in twenty working days. The speed of erection is self-evident, and another reason for economy in this system of concrete block building is that no external plastering is required (merely a pointing of the joints for the sake of appearance), and one coat of lime putty suffices for the interior. The inventor and patentee of the system is Mr. H. A. Hamilton, Thomas Street, Waterford, Ireland. Mr. Hamilton manufactured all the blocks for the villa here illustrated by means of two two-motion concrete-block-making machines, also of his own invention. We are informed that the appearance of the villa has given the greatest satisfaction, and that the walls very closely resemble cut-stone. The roof is slated, and it occurs to us that by substituting a concrete roof a further diminution in cost would be achieved



A Concrete Block Villa nearing Completion.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Roads and Transport Congress and Exhibition.—We would remind our readers of the above Congress and Exhibition, which takes place this month at the Royal Agricultural Hall from the 20th to the 27th inst.

Classes for the Study of Reinforced Concrete Construction.—A course of lectures to study structural design in reinforced concrete is being held during this winter at the Westminster Technical Institute, Vincent Square, Rochester Row, S.W.1. The classes are held on Fridays, 6.30 to 8.45 p.m. The lecturer is Mr. E. H. Sprague. Another course of lectures takes place on Thursdays at the same time, having particular reference to the requirements of the London Building Acts. Lecturer, Mr. E. S. Andrews.

Concrete Blocks and By-laws.—After a long argument the Skegness Urban District Council decided to sanction the plans put in by a local builder for a house to be erected of concrete blocks, 3 in. thick on the outside and 2 in. on the inside, with 2 in. of space between. The town surveyor (Captain Jenkins) gave it as his opinion that the blocks were not of sufficient thickness, and pointed out that the construction contravened the by-laws. The chairman said that as the proposed building was two storeys high, he was inclined to agree with the official.

Dr. Sweeton said he should be one of the last to oppose experimental building in these days merely because it contravened the by-laws. To be candid, he did not altogether agree with the by-laws. The plan was passed subject to minor alterations.

Concrete and Asbestos Houses.—An experiment in the erection of houses built of concrete and of asbestos is being made in the suburbs of Leeds. Mr. J. H. Milner, solicitor, and his son and partner, Mr. James Milner, are building one asbestos and five concrete bungalows in Nursery Lane, Moortown, which is in the area of the Wharfedale Rural District Council. The asbestos house has already been completed and the concrete bungalows, it is expected, will be ready for occupation within two months from the commencement of operations. The architect, Mr. Castelow, estimates that a house costing £800, exclusive of land, if built of stone, and £700 in brick, will involve an outlay of only £600 if built in concrete and £500 in asbestos. It is said that the concrete houses will be the first of their kind to be completed in Leeds.

Willesden Housing.—We understand that the Ministry of Health has refused to allow Willesden to build two concrete houses as an experiment. It was estimated that they could be built at half the cost of brick houses.

Bungalows of Concrete.—Harrow Council has approved of the erection of a number of bungalows of concrete blocks on its housing scheme site. The proposal to provide Army huts as a temporary measure has been abandoned. It is stated that the bungalows can be erected within ten weeks.

Concrete Houses.—To cheapen building the local authorities for Tiverton, South Molton, and Dulverton have a scheme afoot for the making of concrete blocks out of local material. It is estimated that on the erection of 500 houses something like £40,000 will be saved.

Concrete Pipe.—American troops in France made 100 miles of concrete pipe for the use of American armies abroad.

The Use of Concrete in Chile.—Some interesting concrete construction work has been carried out in connection with the laying of a 98-kilometre water conduit in Chile for the water supply of a copper mine and camp in Chile.

In connection with the pipe line there were constructed two reinforced concrete storage tanks of 1,500 metric tons capacity, each (61½ ft. in diameter by 18 ft. net, and 20 ft. gross depth). The most interesting work, however, was in connection with the telephone communications. Wooden poles had often failed in this region from a sort of dry rot at the ground surface. They were practically unobtainable, and when they could be got the price was excessive—above $14 each. It was therefore decided to use concrete poles where possible. They were used throughout except for 200 old pipes and two old rails which were on the roughest part of the upper end of the line. The concrete poles were 6 by 6 in. at the bottom, 5 by 5 in. at the top, and 18 ft. long, with corners bevelled 1 in. They were reinforced with four ½-in. square deformed steel bars, one near each corner, tied together with iron hoops from used cement barrels. The concrete was composed of 1 cement to 4 ore tailings (voids averaged 22 per cent. in tailings) and were cast at the plant on a concrete platform built for the purpose, using wooden side forms. The cost was $10.25 per pole. The concrete was mixed in a 6-ft. mixer, and the poles were strong enough to handle in three weeks.

A few 24-ft. and 30-ft. poles were made for special cases, they were of the same materials and dimensions as the 18-ft. poles except in length. Poles were set an average of 3 ft. in the ground, sixteen to the kilometer (205 ft. apart, average).

Concrete Water Pipes.—Mr. C. H. Priestley, the Cardiff Waterworks Engineer, has presented an important report to a special meeting of the Cardiff Waterworks Committee. In it he deals with the recent visit he paid to France and Belgium for the purpose of investigating the "Bonna" system of reinforced concrete pipes for water supply purposes. The system, he says, is already in use in Swansea, and the pipes are as good as when they were laid in 1905. A similar pipe line exists at Glasgow, and the Birmingham Corporation have recently placed a contract for a very large pipe line of the same kind from the Elan Valley Works to Birmingham. He recommends the use of the pipes for the second line now required from Taff Fawr to Cardiff, in the event of the cost being less than that of cast iron or steel. The pipes are to be manufactured in the district in which they are laid, with the employment of local materials and labour to a large extent. The Committee unanimously endorsed the recommendation.

Trunking for Signal Wires.—While not entirely new in signal construction, concrete trunking has been used extensively in the past three years by the New York Central Lines with good results. The scarcity of good cypress wood, together with the high cost of the sizes required for large installations, has led to the development of concrete trunking of a design that can be made and installed at a cost comparing favourably with that of wood trunking.

The smallest size with 4 sq. in. of wire space is adapted for track work at automatic signal and cut section positions, while the largest size with 64 sq. in. of wire space is large enough to accommodate, with the required percentage of free space, practically any installation. An exception has been found at a certain interlocking where it has been necessary for a distance of approximately 100 ft. to make a special size with 80 sq. in. of wire space. The intermediate sizes of 8, 24, 38, and 56 sq. in. of wire space enable any requirements to be met. A wire rack is used in the four larger sizes, and this, in conjunction with drainage holes cast in the trunking pieces, keeps the wires practically free of water, especially when the trunking is installed clear of the ground.

Method of Construction.—Two sheets of perforated metal lath with a ¾-in. mesh provide the necessary reinforcement for the trunking and the capping, and considerable time is saved in manufacturing on account of the ease with which it can be formed. In the reinforcement for the capping no bending is necessary, and it is possible to get the material in stock sizes from which there will be no waste. Originally the trunking and capping were reinforced with a ¾-in. mesh netting made of No. 14 B.W.G. galvanised steel wire with soldered joints; but a good deal of trouble was experienced in getting this netting when required, and it was difficult to bend it to the proper shape on account of the stiffness of the mesh and the set given the material when made into rolls at the mills. The design of the piers is such that they can be used for intermediate or end supports, and when a change is made in the size of a trunking run a standard pier can be used, avoiding almost entirely the construction of special piers.

The original intention was that the trunking, capping and piers should be made at the site of the work, and with the exception of a small portion this practice has been followed until recently, when approximately 3,000 ft. were obtained from a concrete manufacturing firm. The original method of casting was to arrange the forms as a trough and place approximately ½ in. of concrete in the bottom of the form, after which one of the reinforcing sheets was put in. Above this 1½ in. of concrete was placed with the second reinforcing sheet on top, and ½ in. of concrete to finish the base. The core was next put in and held in place rigidly while the remainder of the concrete forming the sides of the trunking was poured. After setting from 48 to 96 hours, according to the temperature, the forms were removed; first by taking out the collapsible core and then by lowering the sides which were fastened to the base by lugs. Some difficulty was found in doing this, but was overcome by casting the trunking upside down. This method eliminated the use of special forms and has proved both cheap and satisfactory. It is necessary to have a perfectly level floor-space on which to carry out the work. The casting of the piers presented no special difficulties.

The trunking is easily installed, and labourers may be used, under competent supervision. At interlockings where the main trunking is run parallel with the track, it is possible to follow the track curvature and elevation without cutting. Junctions with cross leads at the same elevation are made by cutting out one side of the run and at lower elevations by cutting through the bottom of the main trunking and placing the cross lead underneath. The small size when laid in ballast is more difficult to instal, although with competent help, after a little experience, the time required for installation is not greater than with wooden trunking, and may even be less.

Advantages.—The expenses of maintenance are practically eliminated, no painting is required, either when installed or afterwards, and as each piece is as good as the rest, it is unnecessary to make periodic renewals of certain pieces as when wood trunking is used. This is especially true of trunking laid in ballast. The product is of such strength and stands repeated handling so well that it is particularly advantageous for use where changes in track are contemplated or when temporary signalling is installed. Experience has shown that concrete trunking may be moved as required, and does not have to be thrown away when changes are made. The life of the product is unknown. but it is certain that a well-made installation will outlast other materials that have been used for this work. When run under a track concrete trunking eliminates to a great extent the chance of fire from lighted ashes igniting the insulation of the wires, and also affords protection against crossed wires caused by picks or tamping bars breaking through the wood trunking.—*Times Engineering Supplement.*

Researches in Rodding Concrete.—In a letter to *Engineering News-Record*, Professor F. E. Giesecke, Texas University, refers to some researches made at the University of Texas to show the value of "rodding" concrete; that is, of agitating the new and wet mixture with a pointed iron rod. Some tests were first made at the above University last year and since that time further results have been reached. In one series fifty-four 6 in. by 12 in. cylinders were used. The concrete had the following composition:—

Material.	Percentage.
Cement	14·40
Passing 35-mesh sieve	4·35
Passing 12-mesh sieve and retained on 35-mesh sieve	9·00
Passing ¼-in. sieve and retained on 12-mesh sieve	13·00
Passing ¾-in. sieve and retained on ¼-in. sieve	29·50
Passing 1¼-in. sieve and retained on ¾-in. sieve	29.75
	100·00
Water	10·00

The 54 cylinders were divided into three groups of 18 each. In each group one cylinder was not rodded, the remaining 17 were rodded at stated intervals from 1 to 17 times. In one group a 10-min. interval was allowed between roddings; in another a 20-min. interval; and in the third group a 30-min. interval. The first rodding was applied soon after the moulds were filled—*i.e.*, without waiting for the full interval of time assigned the particular series to pass. By one rodding is to be understood the pushing of a pointed iron rod into the concrete, to the full depth of the concrete, once for every surface area of about 3 sq. in.—*i.e.*, about ten times for a 6-in. cylinder.

It is interesting to note that the maximum strength is about 130 per cent. more than that of the unrodded specimens and that all three series acquired their maximum strength in about 2 or 2½ hours. It is probable that the length of time and the number of roddings necessary to secure the maximum strength vary with the temperature and with the percentages of cement and water.

A second series of lists comprised thirty-six 6 in. by 12-in. cylinders arranged in 12 groups of three cylinders each. The intermediate group was made of concrete having the same composition as for the first series, but the mixing water was 7 per cent. for three cylinders, 8 per cent. for three, 9 per cent. for three, and 10 per cent. for three. This concrete contains cement at the rate of about six sacks of cement per cu. yd. of concrete.

The two other groups are of similar composition, but the cement content changed to about four and eight sacks, respectively, per cu. yd. The percentages of water for the lean mixes were the same as for the intermediate, but for the rich mixes they were increased, respectively, to 7½, 8½, 9½, and 10½ per cent.

To compare these results with the strength of plain concrete, the work of the Lewis Institute of Chicago, as reported by Professor D. A. Abrams, was selected as being probably the latest and most reliable, and probably also the most appropriate, since it gave special attention to the effect of excess water on the strength of the resulting concrete.

According to the Lewis Institute tests, the strength of concrete is a function of the ratio of the volume of water to that of the cement used in the production of the concrete, and is $1,400 \div 7^x$ pounds per sq. in. for cement 28 days old, x being the ratio referred to and the weight of one cu. ft. of cement being assumed as 94 lb.

From diagrams made it was shown that the effect of rodding concrete is more beneficial with lean than with rich mixes, that it is more beneficial with wet than with dry mixes and that the average strength of eight-sack concrete can be increased about 45 per cent. by rodding; that of six-sack about 60 per cent. and that of four-sack about 220 per cent.

Unusual Concrete Retaining Wall Section Has Raised Heel.—In a recent issue of *Engineering News-Record* Mr. R. C. Chaney describes the construction of a rather unusual type of reinforced concrete cantilever retaining wall on a section of the Columbus, Ohio, flood protection work, necessitated by local conditions. A circular bin containing 25,000 bu. of wheat was located within 17 ft. of back of the wall, which was to be placed in excavation extending to 15·2 ft. below the foundation of the bin. It was considered unwise to continue the planned heel of the wall past the bin, as the excavation of a trench within less than 9 ft. of the bin might result in its collapse.

Accordingly, the heel was raised 11 ft. up the back of the wall, and placed on solid earth at that point, where it will act as the toe of the wall under high-water conditions and as the heel under low-water conditions.

This resulted in economy of excavation and was of advantage to the contractors in simplifying the construction problem. This particular piece of retaining wall was part of a levee wall which has a maximum height of 32 ft. and is 633 ft. long.

A Portable Concrete Mixer made from an Oil Drum.—By the mounting of an old oil drum on a pair of concrete buggy wheels, a portable mixer was devised on a job in America, and proved efficient and convenient in laying sidewalks and driveways. In operating it, materials are handled but once. The cart is filled at the gravel and stone pile, churned and pushed to the spot where the concrete is to be placed.

The outfit, with a capacity for a ⅓-bag batch, comprises an old oil drum, mounted on two old buggy wheels about 4 ft. in diameter, having 1-in. pipe axle and pipe fittings. A hinged door is made to close down tightly and is then clamped, and thereby any leakage of water is prevented. The interior of the drum is equipped with mixing blades properly arranged to throw the materials away from each end of the drum toward the centre, as the drum revolves.

POINTS *for* CONTRACTORS!

IN ORDER TO GET THROUGH YOUR URGENT RECONSTRUCTION WORK QUICKLY, WITH SATISFACTION TO YOUR CLIENTS, AND WITH PROFIT TO YOURSELF, YOU REQUIRE :—

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A New System for Building Reinforced Concrete Ships.—Mr. Herbert Fairbrass, a naval architect and an inspector under the Admiralty, has devised a new system of steel reinforcement for concrete ships for which an increased strength in the complete structure and reduced costs are claimed. The main features are the use of bulb sections for the frames and other main members and the provision of slots therein to receive a framework of diagonal rods. The latter consists of a single, double or staggered grouping of wires or rods extended diagonally in a zigzag manner and traversing the outer and inner surface of the frame members through T-shaped slots. Where the transverse thickness of the shell or concrete skin permits, a supplementary grouping of wires or bars arranged vertically and carried on joggled longitudinals may be disposed internally between the outer and inner framework.

The system is extremely flexible in its application and allows the designer very wide latitude in the preparation of his plans and the deposition of his reinforcements. For instance, the slots may be disposed on the outer and inner edges of the frames up to, say, the turn of the bilge, the topsides carrying only a single range of slots, thus considerably reducing the thickness of the concrete shell. Again, the rods forming the metal framework may vary in thickness and show a series of heavy bars of sufficient tensile strength to provide for the longitudinal bending strains, with the intermediate rods of lighter gauge, and the spacing of the slots varied to suit the required size of mesh which in itself is regulated by the spacing of the frames and distance apart of the slots. The latter in their turn can be arranged to give either a square opening, or a diamond-shaped formation, the length of the diamond running either vertically or longitudinally according to the disposition of the slots and spacing of the frames.

Concrete Motor Ships.—The concrete motor ship *Linnea* ran her trials recently from the yard of the A. G. Betonverken at Malmo. She is 132 ft. in length, with a beam of 29 ft. 7 in. and a d.w. capacity of 700 tons. She was constructed for the A. G. Betongett, of Malmo, and is fitted with two oil engines.

Institution of Civil Engineers.—We beg to call attention to a new series of publications issued by the above Institution. The first number of which appeared in October.

The Council have recently decided to issue in pamphlet form Abstracts of Papers in Scientific Transactions and Periodicals as distinct from the Minutes of their Proceedings, instead of having them printed—as they have been since 1875—as "Section III" of the "Proceedings."

This arrangement will render the Abstracts available more promptly and regularly than in the past. The numbers will be compiled and printed quarterly.

The general aim of the Abstracts is, to give brief summaries of the more important engineering and other scientific information contained in current periodicals published outside the United Kingdom, the articles abstracted being selected by experienced engineers.

The New Duluth Pier.—The new pier of the Duluth, Missabe and Northern Railroad U.S.A., is said to be the largest ore-shipping pier or staith for iron ore in the world. It is 2,440 ft. long and 76 ft. wide on the top, while its deck or floor is 85 ft. above the water. Beneath the deck there is a bin or bunker 40 ft. deep at the sides and 6 ft. at the middle, the inverted V-shaped floor dividing it into two compartments with floors sloping to the hinged spouts or chutes through which the ore flows to the hatches of steamers and barges. Cross walls 12 ft. apart divide the bunker into 384 pockets or bins, each of 6,540 c. ft. capacity. On the concrete deck there are four lines of rails, with openings between the rails so that the 50-ton hopper bottom ore wagons can drop their contents directly into the bins. The foundation is a concrete slab 6 ft thick and 70 ft. wide, supported on closely spaced timber piles. Upon this there is a steel superstructure consisting of two rows of columns supporting the girder framing of the bunker and deck. The cross walls and inclined floors are of concrete, while the vertical side walls are of steel. The lower portion is open. This structure is designed to carry 304-ton Mallet engines and 260-ton ten-coupled bogey engines with 27-ton axle loads. The chutes are operated by electric motors, each motor handling twelve chutes. The approach is a 3,100 ft. double-line steel viaduct with 500 ft. of embankment between concrete walls.

PERSONAL.

Sir Henry Alexander Miers, D.Sc., F.R.S., Vice-Chancellor of the University of Manchester, has been appointed by an Order of Council, dated October 16th, 1919, to be a member of the Advisory Council to the Committee of the Privy Council of Scientific and Industrial Research.

TRADE NOTES.

Steel Sheet Piling.—The British Steel Piling Company, Ltd., have just issued their *Bulletin No.* 71, dealing with steel sheet piling, pile driving equipment, and contractors' plant. The publication contains much useful information and a number of tables for reference purposes. Copies can be obtained from the company at Dock House, Billiter Street, E.C.3.

Paint for Concrete.—Our attention has been called to a paint for concrete known as "Walldeco." The "Walldeco" paints are prepared in a large number of shades specially adapted for dwelling houses, farm buildings, roof tiles, etc. A varnish under the same trade name is also supplied for certain classes of works. For full particulars apply to J. C. Bottomley Emerson, Ltd., Brighouse, Yorks.

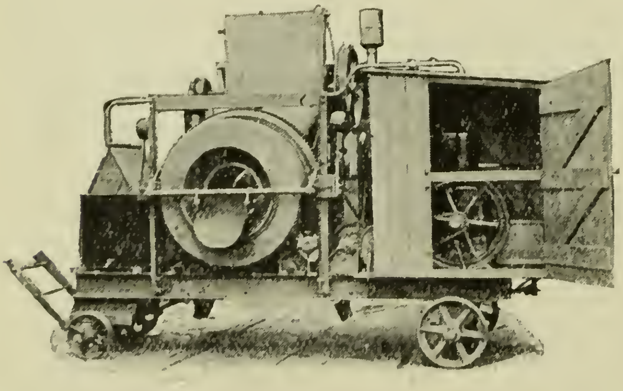
CHANGE OF ADDRESS.

The Concrete Utilities Bureau.—We would draw the attention of our readers to the fact that the Concrete Utilities Bureau have removed their offices to 35, Great St. Helen's, Bishopsgate, E.C.3.

PUBLICATIONS RECEIVED.

Private Companies, their Utility and the Exemptions they Enjoy. 1s. 4d. *Reminders for Company Secretaries.* By Herbert W. Jordan. 11d., post free. Both published by Jordan & Sons, Ltd., 116–117, Chancery Lane, W.C.2.

Departments of Technology, City Guilds of London Institute Programme for Session 1919–1920. Published by John Murray & Son, Albemarle Street, W.1. Price 2s. 6d.



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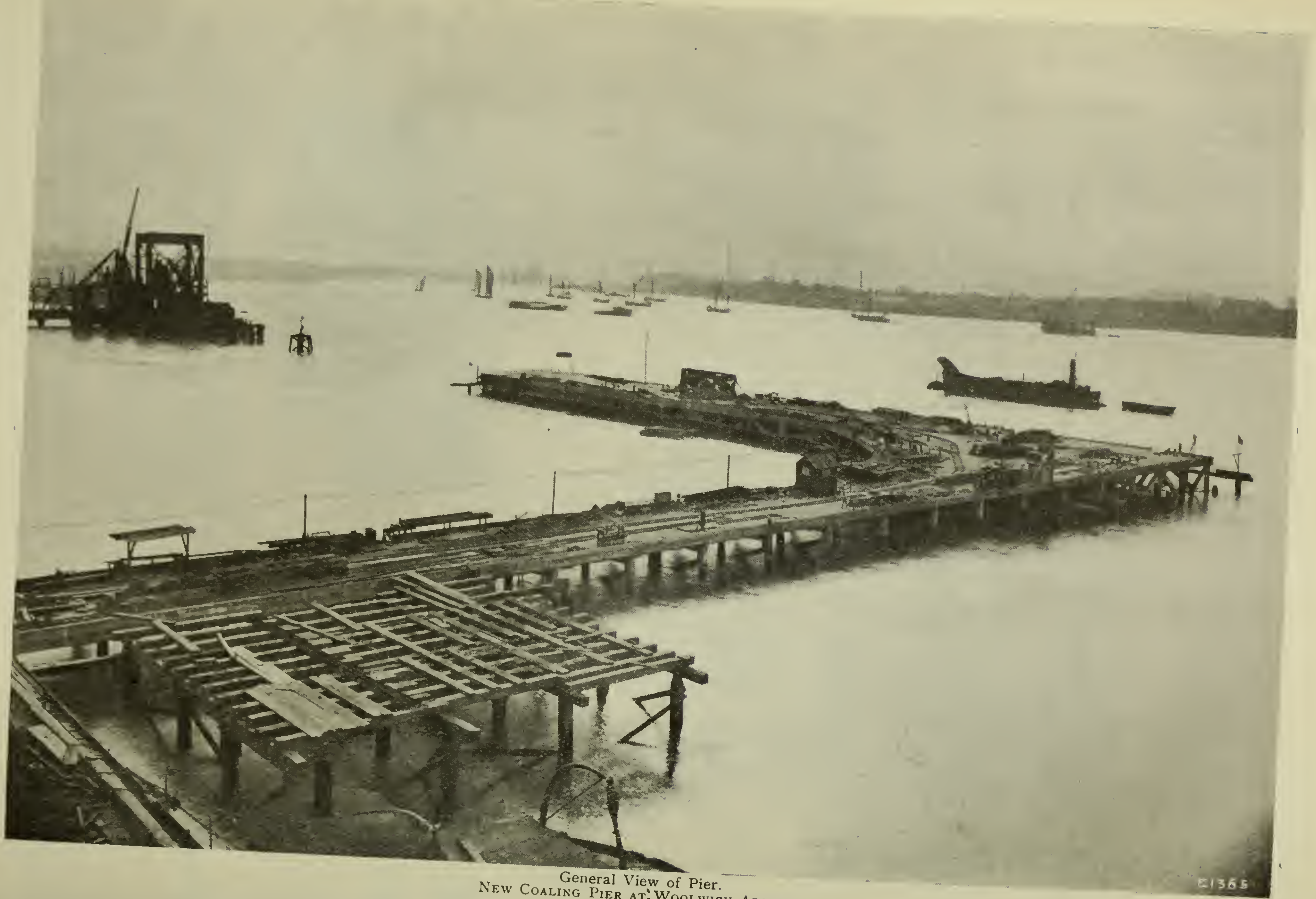


General View of Pier.
New Coaling Pier at Woolwich Arsenal.
(*See page* 701.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XIV., No. 12. LONDON, DECEMBER, 1919.

EDITORIAL NOTES.

CONCRETE WORK IN WINTER.

In these days of speed and time limits for building contracts, a word of warning should be given as to the danger of executing concrete work during frosty weather without proper precautions being taken. All materials which are manufactured on the site of the actual building during the progress of the work are liable to damage by frost if same should occur before the work is sufficiently hard, and a great deal of defective work has resulted from this cause in the past. The reason is, of course, quite simple and natural, as during the action of freezing, expansion takes place which causes the particles to separate, and disintegration follows in due course. Plaster work will crack and fall, the mortar in brickwork crumbles away, and concrete scales or crumbles according to the severity of the weather and the nature of the exposure. The difficulty of executing concrete work in the winter has been put forward on many occasions as an argument against the use of the material, but the same reasoning applies to brickwork and any permanent form of construction, and there are only two alternatives—viz : (*a*) All work must be suspended during a severe frost, or (*b*) proper precautions must be taken to prevent the work being adversely affected.

SUSPENSION OF WORK.

This is often a serious matter both for the contractor and the building owner, because it means that the men engaged on the work cannot be kept constantly employed, and in consequence, some difficulty will be experienced in keeping a good working gang together, and when suitable weather occurs full advantage cannot be taken of the conditions. The building owner will suffer by the delay in the completion of the contract, and general dissatisfaction prevails.

On many contracts the work can be so arranged that during the mild weather the placing of concrete is proceeded with as rapidly as possible, but when the temperature falls to less than 35° Fahr., then the labour is not suspended entirely, but diverted on to the bending and placing of steelwork and the erection of forms. In this way a large amount of work is prepared ahead of the concreting, which allows the latter to proceed uninterruptedly during the mild weather, and the men are kept constantly employed. On one large contract the clerk of works insisted rightly on all concrete work being suspended when the thermometer indicated a temperature of 32° Fahr., and he called upon the contractor to keep a thermometer in a suitable position on the work to indicate to the foreman when work must cease. It was found, however, that every thermometer that was placed within reach of the workmen was broken, and on several days no thermometer was available, and men started mixing and placing concrete because they insisted that although it was cold there was no frost, and they had destroyed the instrument that would have been conclusive evidence against them. Such a difficulty as this can, of course, easily be overcome, but the example is quoted merely to show how dissatisfied the concrete gang were at the prospect of having intermittent employment only. Suspension of the work altogether is, therefore, a bad policy, if there are any possible means of arranging matters so that continual operations can be carried on.

PRECAUTIONS AGAINST DAMAGE.

The execution of work in face of adverse conditions without proper precautions is also a bad policy, as the defects which occur will react on the contractor, and he will suffer in reputation and also financially. In America, where the winter conditions are much more severe than in this country, and where the temperature often falls below zero, concrete work is frequently carried on continuously throughout the winter months, and by taking special precautions no damage is done. These precautions consist in the installation of a simple heating system, whereby steam pipes are carried along to the points where new concrete is deposited, and the temperature is artificially raised and kept at a level which permits the concrete to set without any expansion or freezing. The pipes are arranged with valves and bends to enable constant alterations as required, and simple devices are used to concentrate the heat as far as possible to the air immediately surrounding the new work. Covered chutes from the mixer to the place of deposit are also employed, and care is taken to keep the coarse aggregate and sand from being in a frozen condition during gauging and mixing. Temporary shelters can also be provided over the workmen, and the whole of the new work should be covered up at night, with the addition of a little extra heat, if required. There is no reason why similar methods and precautions should not be employed on all important concrete work in this country which has to be executed in the winter, and the extra expense entailed will result in much satisfactory work and saving of time that it will be well spent.

To simplify the heating and protection, efforts should be made to programme the work in a proper manner, and concentrate the depositing of the concrete at one or two points, because the execution of scattered work will entail long pipe runs, loss of heat, and difficulty in maintaining uniform temperatures. In the case of the manufacture of pre-cast units, the necessary protection is a simple matter, and in some classes of work, where monolithic, *in situ* concrete and pre-cast units are employed for different parts of the scheme, the latter can be made during frosty weather, with suitable shelters to enable the workers to carry on continuously. An example of the successful use of artificial heating to permit the execution of concrete work during frosty weather in this country is provided by the scheme adopted at the B.S.A. works, Birmingham, which was illustrated and described in this journal some months ago.

CONCLUSION.

Contractors should carefully consider the programme of any concrete work which they intend to execute during the winter months, and organise the scheme in such a manner that, in the event of severe frost setting in, there will be no need to suspend operations entirely, and at the same time good and satisfactory work will be executed which will stand the test of time and be a credit to the firm responsible for the scheme.

It is impossible to ignore the laws of nature, and he who attempts to do so will find that payment is always exacted, and this usually in such severe form that regret invariably follows.

RESEARCH.

WHATEVER may be the ultimate effect of the attempts now in progress to organise scientific research, there can be no doubt that the establishment of a Government Department of Scientific and Industrial Research has led to a widened interest in the application of science to industry on the part of large numbers of persons engaged in industry and commerce, and to a more general recognition of the necessity for greater efforts in this direction than have been made in the past, if the industrial prosperity of the country is to continue. Opinions may, and do, differ as to how such efforts may best be made, and manufacturers and others are glad to have some guidance as to the direction to be followed to ensure a reasonable measure of success. The Report of the Department just mentioned has been published for the year 1918–19, and a careful study of its contents is to be recommended to all who are concerned directly or indirectly with the question. It is not the policy of the Department to undertake research or to establish laboratories, with the exception of the steps already taken to deal with the nationally important problem of the more economical utilisation of fuel, which have led to the establishment of the Fuel Research Board with its experimental station at Greenwich. In the main, the policy adopted is that of facilitating the formation of co-operative Research Associations among the members of the more important industries, and in assisting them by means of monetary grants from the fund set aside by Parliament for that purpose. Where, however, a research is of importance to a number of distinct industries, or where the industries are so scattered or so badly organised as to be unable to undertake such a scheme, the Department is able to make grants to institutions or to technical societies for the better prosecution of an approved scheme of work. It should not be forgotten, also, that the Department has now made itself financially responsible for the National Physical Laboratory, an institution which has accomplished admirable work under the auspices of the Royal Society, in spite of limitations due to lack of funds. Pure science, on the progress of which depends that of all forms of applied science, is wisely left unorganised, although it is to be hoped that its claims will not be forgotten in the distribution of funds for the encouragement of research. Without the discoveries of the scientific investigator, unhampered by instructions to solve any scientific problem, the advances in the application of science to industry are bound to remain incomplete and relatively unimportant.

Turning to those items of the Report which are most nearly related to the subjects dealt with in CONCRETE, it may be noted that a British Portland Cement Research Association has been formed and is now at work, although too recently for any details of its activities to be included in the Report. A Building Materials Research Committee has been at work for some time, and it is expected that a report will appear very shortly. This committee has superintended investigations at several different centres, tests of floors having been made at the British Fire

Prevention Committee Testing Station, experiments on the properties of mixtures of lime and cement at the L.C.C. School of Building, Brixton, tests on the passage of gases through various materials for the construction of walls, at the National Physical Laboratory, and tests on thin walls and on the properties of slag and coke-breeze aggregates in other laboratories. A separate committee is dealing with the possible use of certain local materials for building purposes. The public interest taken in the housing question at the present moment, and the fact that the Government has made itself responsible for the progress of housing schemes, have made it essential that researches of this kind should be pushed forward as rapidly as possible, in order that materials may be employed in the most economical manner, due regard being paid to safety, comfort, and permanence. The co-operation of the geologist is evidently called for in this connection, and it may be noted that the organisation of the Geological Survey, which has rendered such excellent services to science and to the nation in the past, is to be taken over by this Department.

By arrangement with the Board of Agriculture, a series of five experimental cottages is being erected on land belonging to the latter body, the experience gained during the work to be utilised by those departments which are concerned with the provision of houses for agricultural workers.

Among the researches which have been assisted by grants a special reference is made to that undertaken by the British Fire Prevention Committee into the ability of various kinds of concrete, plain and reinforced, to the action of fire. This matter is so urgent, in view of the extensive construction with modern materials which will shortly be in progress, that the information obtainable is required as early as possible, and every effort is being made to complete the work. Incidentally, it may be remarked that the researches on refractory materials, undertaken for a different purpose, have a bearing on the same question, and it is desirable that an exchange of information should be brought about. This is one of the functions of a central official organisation such as this, namely, that of serving as a clearing house for information obtained as the result of investigations performed by persons connected with different industries, and dealing, often quite unknown to one another, with cognate problems. Industrial research is best carried on by investigators who are given considerable liberty of choice as to the manner in which they are to attack a given problem, working under the supervision of a body of experts in the industry concerned, the collaboration of a Government department being confined to the approval of the general outline of the proposed work, and to such control of the financial assistance granted as is necessary in the public interest. Fortunately, the terms of the present report are such as to indicate that this is the view taken by the members of the Advisory Committee to the Privy Council, and the account of its activities is therefore gratifying to those who are interested in the progress of industry in the coming years.

EDITORIAL NOTE.

We beg to draw the attention of our readers to the fact that our Editorial office has been removed to 35, Great St. Helen's, E.C.3, to which address all letters relating to the editorial part of the journal should, in the future, be addressed.

A GENERAL VIEW.

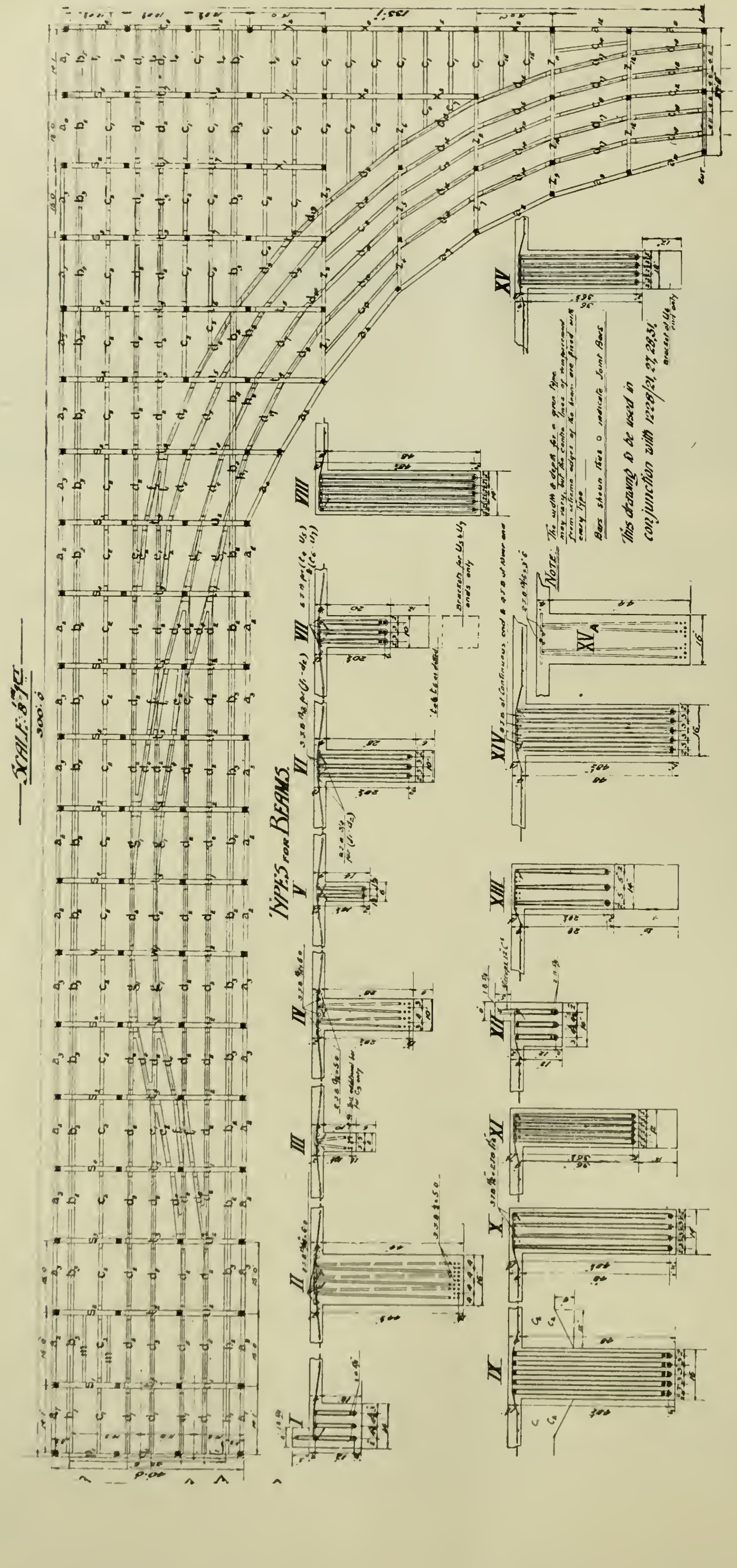
NEW COALING PIER AT WOOLWICH ARSENAL.

A VERY considerable amount of reinforced concrete work has been carried out during the war, concerning which it was not expedient to give any information at the time. We are, however, now able to give some illustrations of an important new coaling pier which was executed at Woolwich Arsenal.

The work was constructed under the superintendence of Colonel N. M. Hemming, C.B., R.E., in accordance with the design and plans prepared by Messrs. Edmond Coignet, Ltd., of Westminster, acting as specialist engineers for the reinforced concrete.

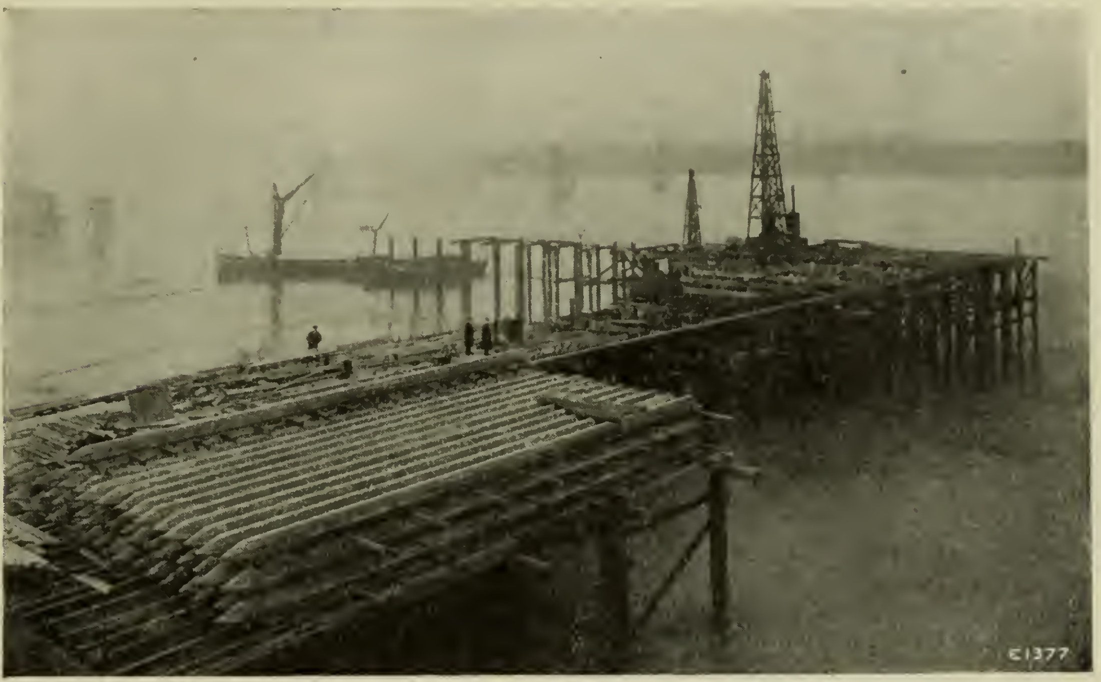
The object of this new pier is to relieve the congestion on the existing coaling pier, and also to carry an efficient conveyor plant to feed the new 3,000-ton reinforced concrete bunker adjoining the pier. In addition to the conveyor plant the main portion of the pier carries a heavy transporter crane which is worked by electricity, and which spans the entire width of the pier. The central part of the deck carries two standard lines of railway supported on timber sleepers. The pier is in the shape of an L in plan ; the approach has a length of 255 ft. and a width of 27 ft., except in the part adjoining the main body of the pier, where the deck curves round to suit the double railway track. The main body of the pier parallel to the river front is 300 ft. in length, and has a total width of 40 ft. The whole area of the deck is divided up in bays of approximately 15 ft. by 13 ft. The deck of the approach has a gradual rise from the old quay wall to the deck of the main body of the pier, as this is at a somewhat higher level than the quay wall.

The approach is supported by 53 reinforced concrete piles connected by one row of horizontal braces for the ten first bays ; from this point, however, and throughout the main body of the pier, two rows of braces have been provided on account of the greater height of the piles and upright members carrying the deck. Diagonal braces have also been provided both in a vertical and horizontal plane in


SCALE: 8 FT = 1 INCH
TYPES FOR BEAMS
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVA
NOTE.
The width & depth for a given type may vary, but the centre lines of compressed from extreme edges of the beam are fixed with every type
Bars shown thus ○ indicate Joint Bars
This drawing to be used in conjunction with 1228/21, 27, 28, 31.
Brackets for U4 & U5 ends only

General Plan of Pier.
New Coaling Pier at Woolwich Arsenal

order to stiffen thoroughly the structure against the impact of ships coming alongside. The main deck is supported by 84 Coignet piles 16 in. octagonal and 53 ft. long, and weighing about 5 tons each. After these piles had been driven to the required set, they were stripped to the steel at a point where bracing is connected. The ends of the reinforcing bars of the braces were interlaced round the steel of the piles and the braces and joint then constructed *in situ*. The floor of the deck, which is 4 in. thick, is supported by reinforced concrete beams which are arranged and calculated principally for the purpose of carrying the very heavy rolling loads of the travelling transporter crane and the railways.



Another view of the Pier during construction. Notice the Piles in the forefront.
NEW COALING PIER AT WOOLWICH ARSENAL.

The reinforcement used for the various members of the structure is composed of round bars varying in diameter from $\frac{3}{16}$ in. to about $1\frac{1}{2}$ in.

The piles contain a certain number of vertical bars surrounded by hoops and ties of small diameter, spaced a few inches apart throughout the length. The braces are also constructed by means of longitudinal bars and ties. The beams contain groups of bars arranged as units of one straight bar and six other bars having their ends bent up at an angle of 45 degrees to counteract where such bar is hooked over a straight bar placed at the top of the beam. All these units for the piles, braces, and beams were prepared beforehand by the steelworkers and tied together with annealed wire so as to keep all the bars in position in the moulds during the concreting. The reinforcement of the deck is composed of a meshwork of principal and secondary bars tied together at every intersection with annealed wire. The piles were constructed on a temporary platform supported by timber piles, as shown in the accompanying illustration, and the piles were conveyed to the pile driver on small trucks. The whole of the pier is heavily fendered in timber to prevent damage to the reinforced concrete work.

The contractors for the work were Messrs. Walter Jones & Son, of Westminster

PRESIDENTIAL ADDRESS.

By H. D. SEARLES-WOOD, F.R.I.B.A.
etc.

The following is an Abstract from the Presidential Address delivered at the opening meeting of the 1919-20 Session of the Concrete Institute.—ED.

It is inevitable that I should commence this my second Presidential Address with reference to the changed conditions of the world since I had the pleasure of speaking to you a twelvemonth ago. At that time an armistice had just been signed, and we none of us knew as to what the future held in store, from the standpoint of whether this armistice would be permanently translated into peace or not, and though even now the terms of peace have not been actually ratified, still to all intents and purposes the world is in a position to settle down to the promotion of the arts and sciences of peace in preference to those that have had during the last few years to be devoted to war.

INDUSTRIAL QUESTIONS.

We are naturally keenly interested as a scientific institution in all problems that when solved, will foster the fortunes of building, engineering, and allied industries. In the Whitley Industrial Councils one sees vast possibilities for good, but I think there should be strong efforts made (as indeed successful efforts have been made in certain quarters) to get beyond the region of abstract consideration and enter that where the abstract ideas can materialise into practical procedure. I think the Concrete Institute should be represented on the Building Industrial Council and that we should give valuable assistance to its deliberations.

It is inevitable that I should make some reference to the industrial unrest that has been such a prominent feature during the past several months. Here again we should not only have patience, but we should be entirely optimistic upon the point. It is in very truth cause and effect, or, if you prefer it, reaction from the war strain. The essential point is to increase output at the present time as far as labour is concerned; this output is 20 per cent. below the pre-war figures, and the difficulty in getting such materials as cement, steel, glass, etc., is a serious hindrance in building operations.

A NATIONAL BUILDING CODE.

We are still waiting for the Royal Institute of British Architects' amended form of contract which is in turn awaiting the Institute of Builders' consideration. The National Federation of Building Trades Employers expect shortly to publish a national building code. But as this is not yet issued I cannot comment upon it; all this, however, goes to prove that reconstruction will take place in the building trade as well as in other industries; whether the architectural profession will accept the code or whether it will be the subject of Government arbitration, as in the case of the Scottish code, it is difficult to say. It is well known that there are many points in the existing form of contract that the building contractor wishes to modify; most of these differences of opinion arise on the lump sum form of contract in the Royal Institute of British Architects' contract. The effect of this form is that the contractor guarantees the whole of the work and the contract, therefore, is most favourable to the employer, because he knows the full extent of his liability upon entering into the contract. But the lump sum contract is too rigid if the employer wants to make alterations in the drawings, which can only be done under this form by entering into a new contract for fixing the cost of such alterations and the terms of adjustment of the same. Contractors now, except in small works, require the incorporation of Bills of Quantities to provide for the purpose of adjusting the payment of work not shown on the drawings.

The schedule contract, which is the Scottish form settled by Sir George Askwith for the Government, and which during the war has been largely used, is as follows :- In this form of contract the Bills of Quantities contain the terms of the contract for the whole of the work and give the rates at which the whole of the work is to be measured up at completion. It transfers the risk of unforeseen accident and difficulties in the carrying out of the work from the contractors to the employer ; at the same time the employer only pays for work which is actually done. In the case of this form of contract every price in the schedule wants careful consideration by the architect and a comparison of the totals sent in by the contractors is not a good basis when considering which tender to accept.

Another form of contract is the prime cost plus profit. When the profit to the contractor is a percentage profit on the whole cost of the work, he takes no responsibility as regards economy, and the architect must assume certain responsibilities for the economic administration of the work. In the Engineering Supplement of *The Times* of January, Mr. E. J. Rimmer gives the particular points to be emphasised, viz. :—

1. That the contract should make the architect's approval of quotation for the purchase of material, rates of wages to be paid to the contractor's staff and the hire price for machinery and plant a condition precedent to payment of these charges.
2. That all payments of whatever kind, and particularly that of the men's wages, should be actually witnessed or proved beyond doubt by someone appointed by the architect on behalf of the employer.
3. That the duty of time-keeping should be assumed on behalf of the employer and not left to persons employed by the contractor.
4. That prime cost should be very clearly defined in the contract and that the expenses incidental to the carrying out of the job should be either expressly included in or omitted from this definition.

These four points are important ones ; they do not in any way impugn the honesty of the contractor, but are merely protection to the employer against the carelessness or dishonesty of anyone in the contractor's employ, by which the contractor will benefit. Another important point is that the employer should reserve the power through his architect of directing the administration of the job from beginning to end. I think that I have said enough here to make it clear that in adopting this form the architect involves himself in responsibilities which he would not care to take upon himself. Lord Selwyn's Committee recommended the form of fixed profits, that is, where the contractor's profit is fixed at a lump sum instead of a percentage on the total cost, and I believe that this form is favourably received by the building trade.

The objections on the part of the profession to this form are :—

(1) The control of the administration of the work is necessarily left in the hands of the contractor by reason of the provisions in his contract, that his profit is fixed and that a bonus will result to him from expeditious and economical results.

(2) I think the foregoing are the chief forms of contract now in vogue ; and the point wherein they most closely affect the members of this Institute is the position that the architect or engineer occupies with regard to the contractor and employer.

Another probable change in the practice of our profession is in the method of payment for our services. The existing percentage basis for our fees has often been objected to, it being considered (quite unjustifiably) that this method is not conducive to strict economy in the cost of the work, and that architects unscrupulously increase the cost of the work in order to swell the amount of their fees. I am sure, as regards most architects, this is a cruel and baseless charge, and that in the vast majority of cases the architect's desire is to get his clients' work done on the best terms possible. But it cannot be denied that the percentage system certainly suggests a reason for remarks of this kind. In America they have a method of charging, known as the fee plus costs system of charges, under which the architect charges a fixed professional fee for his personal services, and, in addition, charges his various expenses at cost.

The cost of draughting and other expenses of the architect involved in the performance of this service, including all overhead costs, are charged to the owner at cost.

This system of charging places the architect in a position where he can advise the owner on the investment of his money without having his professional remuneration in any way affected by the final amount actually expended. The adaptability of the system to the work of public, private, and corporate owners has been demonstrated in actual practice for many years.

THE HOUSING PROBLEM.

I do not propose to say much about the housing question ; I understand the Housing Department have approved 14 different forms of concrete cottage building, and I think the limit must be nearly reached when 3 in. concrete floors without any covering are being approved.

REINFORCED CONCRETE WORK AT THE PORT OF LONDON.

One of the most interesting reinforced concrete buildings now being carried out is the large dome over the Port Rates Department of the new head building of the Port of London Authority. The outside diameter of the supporting walls is 112 ft., and the outside diameter of the dome proper is 110 ft. 6 in. The rise from the centroid of the main supporting tension ring to the centre of the top compression ring is about 31 ft. 6 in. The top ring or dome is a double dome supporting a pendant light, and is carried by 16 ribs, which are open between the ribs and glazed and roofed with glazing. A travelling ladder is to be fixed over the outer glazing for cleaning purposes. The lower two-thirds of the dome are to be constructed in reinforced concrete with 32 internal ribs and 16 external ribs, the shell being stepped with five steps and asphalted on the outer face. The total weight of the dome, including the bottom supporting ring, is estimated at 1,536 tons. The cu. ft. of concrete total 20,000, equal to a length of over 3½ miles of 12 in. by 12 in. The calculated horizontal radial thrust at the foot of each of the 16 main ribs is 22·35 tons, and of the 16 intermediate ribs 14·82 tons, and the hoop tension in the supporting ring is 114 tons The radial thrust can be roughly checked by the following simple formula :—

$$Tr=\frac{\text{weight}\times\text{diameter}}{8\times\text{rise}\times\text{number of ribs}}=21{\cdot}1\text{ tons},$$

and the hoop tension in the main supporting ring can be checked by the following simple formula :—

$$Th=\frac{\text{wt.}\times\text{circ.}}{150\times\text{rise}}=111\text{ tons or }\frac{\text{wt.}\times\text{diam.}}{150\times\text{rise}}$$

This dome was so perfectly proportioned by the architect, Mr. Edwin Cooper, F.R.I.B.A., that the eccentricity of the lines of thrust in the main ribs was practically negligible. These ribs being assumed as 18 in. deep, the maximum eccentricity in the upper portion was 3 in., on the centre portion 1 in., and the lower portion 2 in. Again, the horizontal thrust at the intermediate rings or purlins, due to the main ribs, are almost equal, being 22·35 tons at main supporting ring, 22·98 tons at the lower position, and 22·02 tons at the upper purlin ; therefore the stresses in these two purlins due to the main ribs are practically nil. Broadly speaking, this is an admirable example of a dome, which from an architectural standpoint is perfectly proportioned, and from an engineering point of view is economically designed because all stresses are reduced to a minimum and secondary stresses are eliminated ; in fact, the moments due to eccentricity of thrusts are so small that sufficient steel has been provided to take up all such moments, and the resistance of the concrete has been neglected. No wind or snow load was allowed in calculating the weights, because compared to the weight of the construction, such load is infinitesimal ; in other words, a super-load of about 4,500 tons would be required to cause the dome to collapse.

SCOPE OF INSTITUTE.

I should like just to interpolate here one remark, and that is the desire of the Governing Body of this Institute that members should disabuse their minds of the idea that the Institute's interests are confined to concrete in all its forms. Our interests are indeed far wider, including structural engineering in its widest applications, and the arts and sciences allied to or in any way associated with structural engineering and concrete.

EXAMINATIONS.

I would next like to refer to the scheme of examinations which has been for such a considerable period before the Institute. We are making the necessary arrangements to hold the first examinations next May.

EDUCATIONAL LECTURES.

We are restarting our course of educational lectures, and have arranged for a series of six free public lectures, each lecture being undertaken by a different lecturer ; the subjects will be treated in elementary style to suit the student class, and will be held from February to April at 6 p.m.

ACTIVITIES DURING PAST TWELVE MONTHS.

Properties of Aggregates.—I am sure you will be glad to learn of some of our activities during the past twelve months. We devoted considerable care to drawing up a list of properties of aggregates, with a view of submitting skeleton sheets of questions to the general body of municipal surveyors, and we have had a large response The information received will be co-ordinated by us as soon as the expected replies have all arrived.

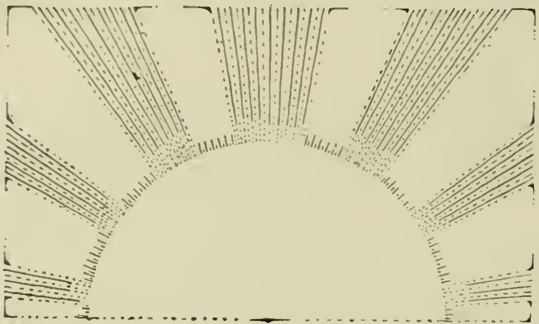
Concrete Shipbuilding.—The Sub-Committee on Reinforced Concrete Shipbuilding continued its sessions, and at present we are preparing a draft report to be submitted to the Council.

Science Sub-Committee.—A short while since we appointed a small Sub-Committee of the Science Committee to consider the British standard specification for cement, with a view of advising as to what amendments might be desirable ; the suggested emendations have been approved by the Council and are now before the British Standards Engineering Association for its consideration.

High-Tension Steel.—The Committee dealing with the question of high tension steel has prepared a series of preliminary tests which are now being carried out. As soon as these are completed the results will be used to formulate even larger tests which it is hoped will be carried out, and thus settle this important point in reinforced concrete.

Cement.—The Science Committee is considering the question of the investigation of cement by means of micro sections and in due course a report on this will be forwarded to the Research Department. It is generally known that a good cement, under favourable conditions, tends to increase in strength with age, and that the action of setting and of such increase in strength is due to hydration. There appear, however, to be but few data available as to the actual change in form of the various components of concrete from a microscopic standpoint, although it is understood that American and German scientists have already carried out some investigations of this character. The bibliography of the subject, however, is not readily available, and we consider that the collection of this should be undertaken together with the other investigations which are recommended in this report. That chemical changes take place in the progress of setting are (and can be) proved by chemical analysis, but such analyses remain to be properly co-ordinated with the micro-structure of the cement or compo during the progress of hydration.

Watertightness is one of the most important requirements of cement and concrete, more particularly in connection with reinforced concrete, and in connection also with their use either in the form of mass concrete or as reinforced concrete for tanks and vessels for containing or excluding liquids. Percolation tests on ordinary concrete have proved beyond question the fact that even with clean filtered water all concrete tends in time to become less porous provided the pieces under test are kept moist, thus proving that the chemical changes produce alterations in the micro-structure tending gradually to fill the small voids with crystalline growths. How these crystaline growths develop is a matter which it is desirable should be carefully investigated, and the only satisfactory method which presents itself at the present time is by examination of the micro-structure of cement and cement compo during development.



A REINFORCED CONCRETE HIGHWAY IN ESSEX.

Last month we described the construction of certain concrete roads in the metropolitan area. We are now able to provide our readers with the particulars of a concrete road being laid on a great highway. The road in question is that which runs from London, through Woodford, to Newmarket and Cambridge, and the portion which is being laid in concrete is the Epping New Road at Buckhurst Hill. This road carries a weight of traffic of some 1,500 tons a day.

The stretch of concrete road originally designed was 500 yards, but owing to strikes and other labour difficulties 235 yards only have been possible to date, and, on account of the approach of winter, and the recognised difficulty of carrying on concrete work in the open during frosty weather, operations on the remaining portion of the 500 yards will be postponed until the spring. When the adoption of this form of road construction becomes more common in this country, as we are convinced it will, we shall, no doubt, devise some means whereby the work can be carried on under all climatic conditions. Such devices are frequently met with in concrete practice in America, and occasionally in Great Britain, and include the heating of the aggregate, the use of warm water in mixing, and the protection of the freshly deposited material from the action of the frost.

The Epping New Road at this point is 27 ft. wide, and since it is a main road, the traffic could not be diverted; one half of the width of the road has therefore been reconstructed at a time, the other half remaining open for traffic. At the time the work was inspected the second half of the road was being laid, although, the day being frosty, the actual concreting had, for the moment, been suspended, the portion recently completed being well protected by a layer of straw several inches thick, and weighted with sacks. Every facility for inspecting the road was afforded by the Essex County Surveyor, Mr. Percy J. Sheldon, and by the courtesy of Mr. W. H. Morgan, the assistant surveyor, we are able to furnish the following details of construction.

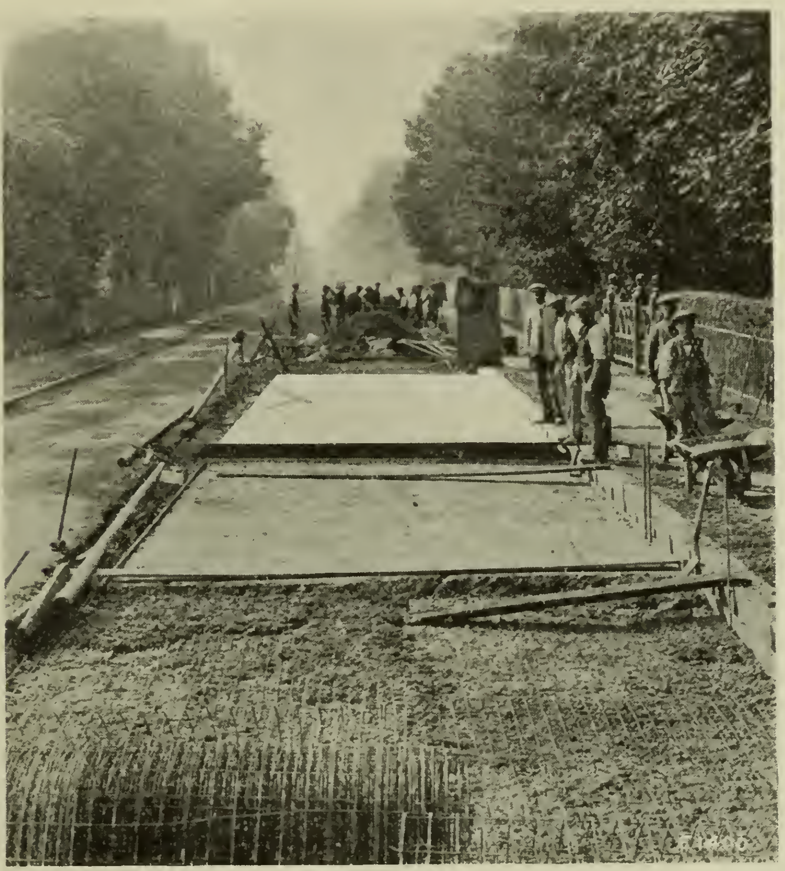
Method.—The two-course method, which both produces a perfectly sound structure and is probably the most economical, is being generally adopted in British practice, and has been carried out at Buckhurst Hill, the lower course being 5½ in. in thickness, and a wearing course of 2 in., making a total of 7½ in. At the channel on each side to the width of a foot from the kerb the depth of the concrete is 12 in.

The mixing is done by hand, and the upper course is laid immediately after the lower, so that the whole forms one monolithic structure.

Aggregate.—For the lower course local ballast is employed in the proportion of 6 : 1, and for the wearing course granite chippings and crushed granite graded from ½ in. down, and mixed in the proportion of 3 : 1.

Foundation.—The original road was macadam, and since the foundation has proved to be thoroughly sound it has received no special preparation other than shaping and hand ramming.

Reinforcement.—The road is reinforced with British Reinforced Concrete No. 9 fabric, which is placed 1½ in. from the bottom. This is seen in the accompanying illustration which shows the road under construction.



The Reinforced Concrete Road under construction at Buckhurst Hill. The reinforcement—B.R.C. fabric—is seen partly in position and partly in rolls ready for laying.

Joints.—No transverse joints are provided, the material at the commencement of each day's work being butted against the vertical edge left at the end of the previous section. Next the kerbs longitudinal joints filled with bituminous material have been provided. In most of the concrete roads now being laid these are omitted.

Camber.—For purposes of surface drainage the road is shaped to a camber of 1 in 50. This is entirely in agreement with modern practice, and, indeed, furnishes one of the arguments in favour of the concrete road, which may be made flatter than any other, with the double effect of avoiding that concentration of traffic on the crown which invariably occurs on highly pitched roads, and enabling vehicles to travel safely along the sides without danger of skidding.

Finish.—The surface is finished by being worked over by a shaped board or " straightedge " until the mortar has been brought to the top. When the concrete is thoroughly dry and hard it is proposed to tar the road.

Curing.—After the concreting is completed the road is kept sprinkled with water for several days ; the traffic was kept off for 21 days in the warmer weather and 28 days during the autumn weeks.

The surveyor is convinced that there is no question as to the strength and durability of concrete for roads, and that their success and efficiency are only a question of workmanship. To this end nothing is being spared with regard to labour, and the faith of this progressive Council and their responsible officers in the ultimate economy of the concrete road is shown by the fact that they have persevered with the construction of the road in question under the most adverse conditions with regard to transport of material. All the bridges that are being renewed in the area administered by the Essex County Council are being constructed in concrete, and there is every reason to hope that an extensive programme of concrete roads will, within the next few years, be carried out.

MEMORANDA.

As showing the intelligent manner in which our dominions overseas are approaching the question of concrete roads, we may instance the case of Mr. Walter E. Bush, M.Inst.C.E., City Engineer of Auckland, New Zealand, who, in March last, was sent by his council on a tour of inspection through America, Canada and the United Kingdom to study the various methods of concrete road construction and to examine their efficiency. Some of the results of his observation were mentioned in a paper read by Mr. Bush at the recent Roads and Transport Congress at the Agricultural Hall. We hope to publish an abstract from this paper in our next issue.

A South of England Gas Company adopts Reinforced Concrete Roads.—The Portsea Gaslight Company early this year decided on the laying of a reinforced concrete road, and a 700 ft. length has now been in use for some months. The roadway in question comprises the eastern half of Green Lanes, which extends from Copnor Road to the entrance gates of the company's Hillsea gasworks. The length of the concrete bed is a little over 700 ft. and its width 22 ft. between the kerbs. No channel stones were required — the gullies being bedded in the concrete, the latter pins the channel. Accordingly the channel stones on the south side of the road were raised and used to form the kerb on the north side, the existing kerb stones on the south side being re-laid on concrete. In laying a new road, however, the kerbs would also be formed in the concrete, thereby obviating the extra cost of stones.

The body of the road is a continuous slab of concrete 6 in. thick, and reinforced with special fabric. The latter is placed near the bottom of the concrete mass, anp consists of a layer of wire meshing, electrically welded at the joints.

The old road was composed of granite—known as water-bound Macadam—and the surface of this was excavated, watered and well rammed to the proper camber. The reinforcing fabric was then supported 2 in. above the prepared ground, and a 6 in. layer of Portland cement concrete applied and well rammed around the fabric. The upper 2 in. being of a fine grade and finished to a proper surface and camber. The concrete was covered with wet sand for some days, and after some weeks its surface was tar-sprayed and dusted over with coarse sand.

The work was carried out to the Gas Company's specification by Mr. John Croad of Portsea, and we understand has resulted in a remarkably fine thoroughfare.

ECONOMICAL HOUSE BUILDING.

A Review.

By ALBERT LAKEMAN.

By the courtesy of the publishers we are able to reproduce a few of the illustrations from the book here reviewed.—ED.

Economy in the construction of dwellings is a subject that interests a large section of the community at the present time, and much energy and thought have been expended in the effort to produce a type of structure which will be relatively cheap, and at the same time comply with reasonable requirements as to durability and accommodation. Numerous suggestions have been made by architects and amateurs in the technical journals and in the daily press, and they cover almost every possible material from the old-fashioned " cob wall " to the modern scientific application of reinforced concrete, and inventions and patents have resulted in large numbers. In many of these suggestions the great factor governing the designs appears to be the necessity for doing something different without regard to the suitability or real economy of the method suggested, and thus we have been inundated with a mass of useless ideas which render the taste of adoption extremely difficult to those who intend to carry out a housing scheme. Economical building calls for more than the evolution of a patent method for erecting the external walls of a structure as true economy can only be obtained by clever planning, and the experienced application of suitable and economical materials for each and every part of the building and its fittings.

A useful book* by Mr. Gordon Allen has just been published which contains a mass of information that will be appreciated by architects and others at the present time, and some extracts and notes from the volume are given in the hope that they will be appreciated by the designers of the many cottages and houses to be erected in the near future.

The " cheap " cottage is undoubtedly a thing of the past, but the definition as here used means simple fitness, restraint and efficiency, as contrasted with elaboration or unnecessary ornamentation, and the adjective is therefore comparative and must be viewed in this sense.

No building can be considered " cheap " at the present time when compared with pre-war cost, but the old prices no longer prevail in any industry, and comparisons with them may be interesting but are practically useless.

The first chapter in the volume is introductory in character, and deals with the general question of the need for providing a large number of suitable houses as quickly as possible, and the author then proceeds to deal with the site and water supply. The selection of the site is obviously a very important matter, and although nothing new is given in these notes the chief points are covered in a simple manner, and the water supply is briefly considered in a general way which will be of more value to the layman than to the architect.

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* *The Cheap Cottage and Small House.* By Gordon Allen, F.R.I.B.A. London : B. T. Batsford, Ltd. Price 8s. 6d. net

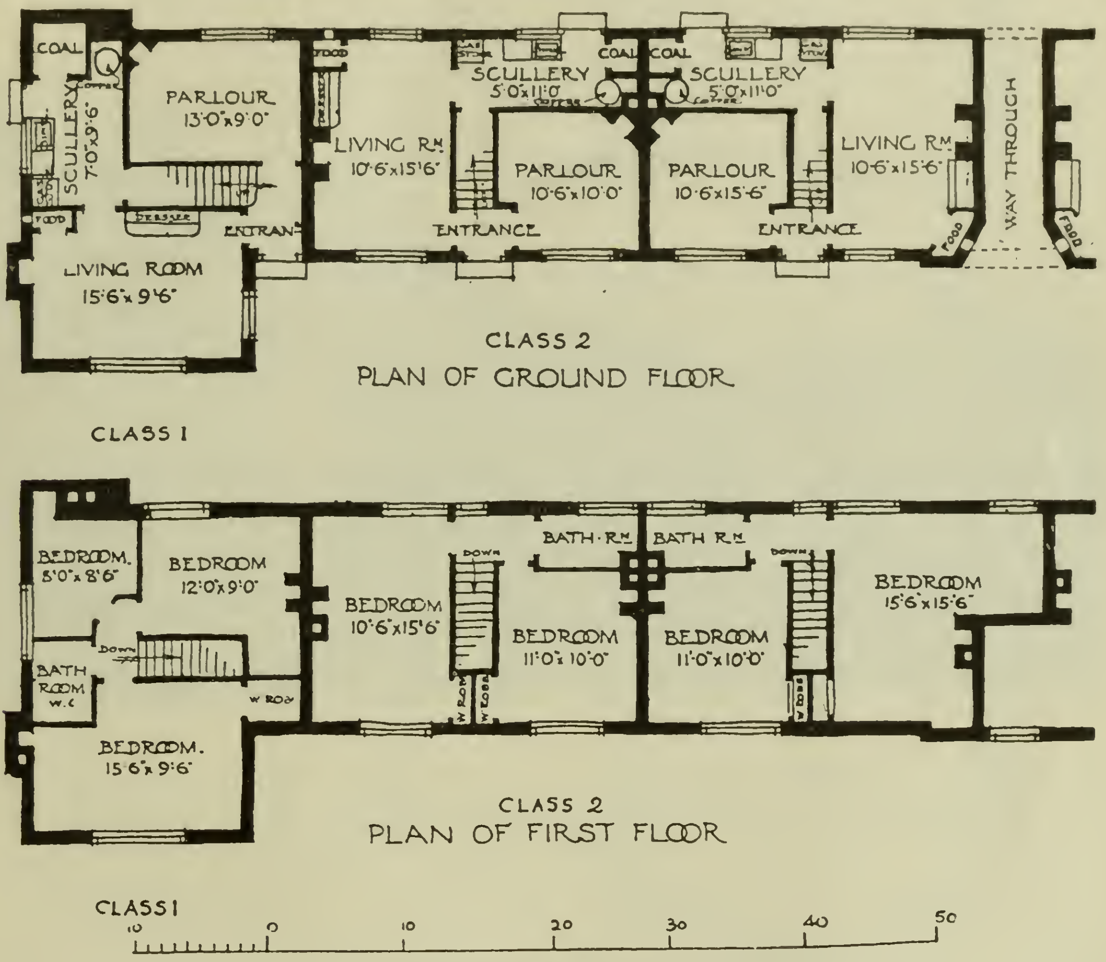
The third chapter is devoted to the consideration of the planning of small houses and cottages to meet the real needs of the tenants, and a word of warning is wisely given against the tendency to imitate the lay-out of a mansion when planning a cottage.

Advice is given on the principal points to consider when making the plans, such as the need of putting on the drawing the chief articles of furniture to scale, the correct arrangement of doors, windows, and fireplaces and similar matters.

Roe Green Garden Village, Kingsbury.

The parlour is advocated because the author considers it is necessary to satisfy the requirements of the average tenant, and there is no doubt that a " best room " is demanded by the great majority, although from a practical point of view it is often waste of valuable space, as it is seldom used and is merely a relic of olden days when such a room was a mark of respectability. Each room is dealt with in detail and suitable sizes are specified. The question of aspect is very important and when a living room and parlour are provided it is not always possible, owing to site limitations, to provide the ideal look-out for each.

Also, where cottages are built in groups, it is desirable to plan one room to give a view of the garden at the rear for many reasons, and in this respect the single-fronted type offers some advantages over the double-fronted type which are not usually sufficiently recognised. The living room should certainly have plenty of sunshine, because the family will spend most of their time here, and this consideration should be the ruling factor in the whole of the plan. The convenience of the kitchen is a matter that cannot be too thoroughly considered, and yet the most elementary points are often overlooked. As an example, we notice the plan of the cottages on the Well Hall Estate, Woolwich, which are illustrated in connection with this chapter, that the scullery (which serves as a kitchen) is planned to give the maximum inconvenience. The copper is placed remote from the sink, and the housewife will appreciate what extra work this entails; the gas cooker is apparently next to the sink and in a dark corner, and the larder necessitates the longest possible amount of walking to and fro when cooking has to be done or the meals laid.



Roe Green Garden Village, Kingsbury.

The author deals with the essential requirements from the housewife's point of view in a very clear manner, and he rightly advocates sufficient light and adequate cupboard space, two items which are commonly insufficiently provided for in cottage work. In dealing with the larder accommodation, however, he states that wooden shelves are almost as good as slate or stone ones, and neglects to mention that at least one slate, concrete or stone shelf must be provided for such articles as milk, butter, and anything that requires keeping very cool, and, furthermore, a type of shelf which can be easily wiped down is necessary for hygienic purposes.

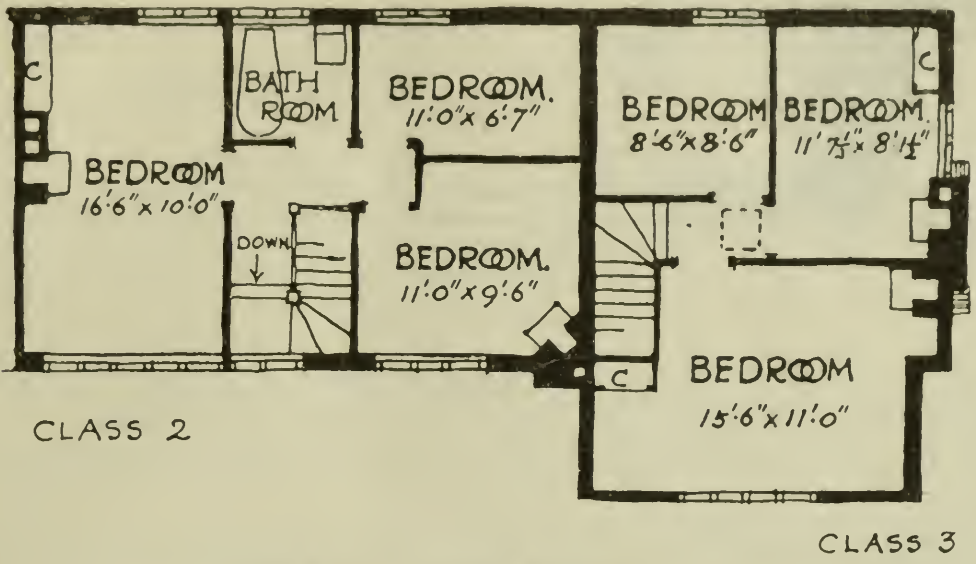
The general arrangements of all the rooms are discussed by Mr. Allen, and some very good hints are given which would result in an excellent plan if they were followed by the designer.

After dealing with the planning of the rooms, the author passes on to the consideration of the exterior appearance, and how economical design is to be achieved, and then treats with interior fittings and finishings.

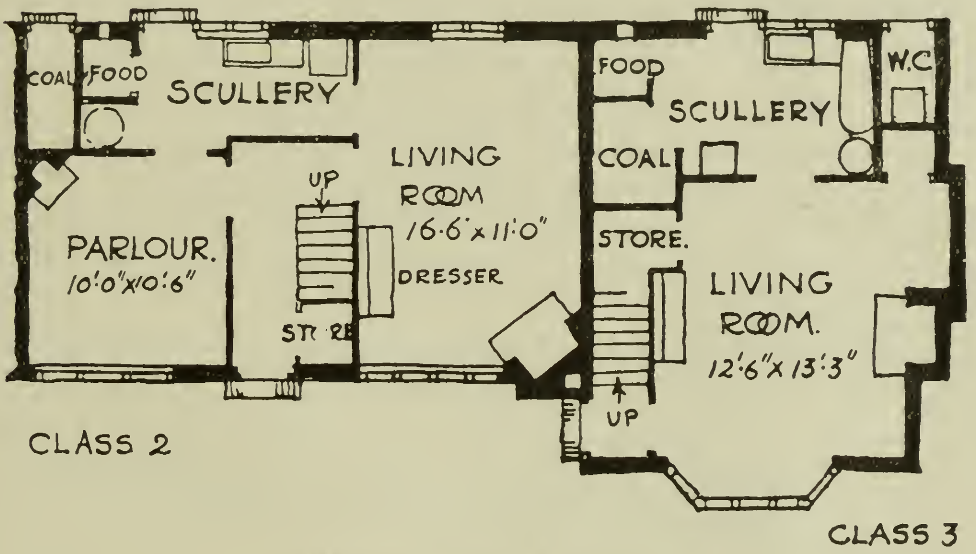
Many useful notes are given in these chapters, and emphasis is laid on the necessity of keeping everything as sanitary as possible by the omission of dust collecting mouldings and similar features. Under the heading of "Materials," the question of economical construction is discussed, and the merits and demerits of various methods are put forward. The advantages of local materials is made a strong point, and rightly so, because economy can only be effected when full use is made of the resources in the neighbourhood of a proposed building. In dealing with concrete walls, the author states that "concrete seems to be the building material of the future," and as reason for this he puts forward the obvious advantages of adaptability and convenience in transport owing to suitable aggregate being generally obtainable in the locality, and cement only having to be carried a distance. Notes are given on the selection of materials for damp-proof courses, wall finishings, and roof coverings, in which effect and economy are duly considered. In dealing with foundations, however, the author advocates brick footings to the walls in addition to the concrete base, and here we think he has missed a very simple point in economy, as brick footings are not really necessary in cottage work, and under the regulations of the Ministry of Health, in connection with the Housing Scheme, they are not required.

WELL HALL ESTATE, WOOLWICH.

Chapters are devoted to sanitary and lighting requirements and to prices of building work, and the question of by-laws and cheap materials is then dealt with. The unnecessary restrictions imposed by obsolete regulations have been the subject of several articles in this journal, and we are, therefore, quite in sympathy with Mr. Allen, who points out, in a very forcible manner, how unnecessary expense is involved through the imposition of ridiculous regulations, which are based on old-fashioned ideas and enforced by inexperienced non-technical public bodies. The volume ends with some useful hints on cottage gardens, and emphasis is laid on the importance of preserving, as far as possible, existing trees and bushes.

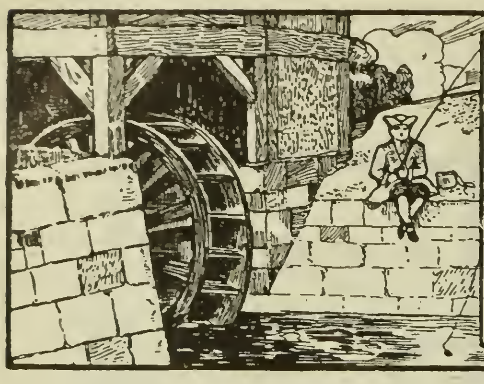


FIRST FLOOR PLAN



Well Hall Estate, Woolwich.

The book is copiously illustrated with plans, elevations and photographs of various types of cottages and small houses, some of which are reproduced here, and the matter is well written, while the large experience of the author in domestic work of all kinds lends a value to the opinions expressed, which should materially assist in the success of the volume.



STANDARD SPECIFICATION FOR COTTAGES.

(*Concluded.*)

166. *Bath.*—The bath is to be cast-iron greenstone vitreous enamelled set on feet, with brass waste, plug, and chain, hot and cold taps, and iron trap, all to standard pattern.

167. *Cocks.*—The bib, stop and ball cocks are all to be brass of approved pattern.

168. *Testing.*—Test the whole of the internal plumber's work, water supply and fittings, and leave in perfect working order at completion.

HOT-WATER FITTER.

169. *Pipes.*—The pipes are to be wrot iron welded steam tubing as previously specified for water supply except in districts where lead or copper pipes are necessary, when they are to be as hereafter specified.

170. *System.*—The hot water supply may be provided by means of either the tank or the cylinder system, or where the bath is on the ground floor and not far from the boiler, an approved " Gravitation " system. N.B.—In each case the system proposed to be adopted must be specified and comply with the following requirements :—From the cold water cistern take a ¾ in. galvanised steam barrel supply to the hot water apparatus, with a screw-down stop-dock in same just under cistern. The tanks or cylinders are to be 14 gauge tested galvanised wrot iron of 30 gallon capacity, with bolted manhole in same and with flanged connections for pipes. The flow and return pipes are to be not less than 1 in. diameter, and in districts where the water is hard the flow and return pipes are to be not less than 2 in. diameter for 6 ft. above boiler. From the flow pipe near the boiler take a branch to a convenient position and fix thereon a dead-weight safety valve. Take ¾ in. branch to the bath and ½ in. branches to sink and lavatory basin. Provide ¾ in. expansion pipe delivering over the cold water cistern. Form draw-off at lowest point in system with ½ in. tubing properly connected to same, and provide and fix bib cock to empty system.

171. *Lead or Copper Pipes, and Copper Boiler and Cylinder.*—In districts where iron pipes, boilers, and cylinders are not serviceable, the pipes are to be in lead or copper, and the boot boilers at back of the range and the cylinders are to be of copper. The lead pipes are to weigh as follows :—½ in. diameter, 6 lb. per yd. ; ¾ in. diameter, 9 lb. per yd. ; 1 in. diameter, 12 lb. per yd. ; 1½ in. diameter, 18 lb. per yd. The copper pipes are to be of No. 10 gauge. The copper boot boilers to be 3-16 in. plate to hold 3 gallons, with bosses brazed on and tapped for connections to pipes. The cylinders are to have No. 22 gauge copper body and top, and No. 18 gauge bottom with bosses brazed on and tapped for connections to pipes.

172. *Testing.*—Test the whole of the hot water service and leave in perfect working order at completion.

GAS OR ELECTRIC LIGHT SUPPLY.

173. *General.*—Arrange with the local gas or electric light supply undertakers for the gas lighting and cooking or electric light installation complete.

GLAZIER.

174. *General.*—The windows are to be glazed with seconds 15 oz. sheet glass except where the squares exceed 1 ft. 6 in. superficial area, in which case 21 oz. sheet glass is to be used, well-bedded, sprigged and puttied. Front door and w.c. and ground floor bathroom windows are to be glazed with approved obscured glass. All glazing rebates are to be primed. All putties are to be painted two coats.

PAINTER.

175. *Paint.*—The paint is to be obtained from an approved manufacturer, supplied ready mixed for use, of approved plain tints. The paint is to be used as sent by the manufacturer, and each coat is to be of a distinctive colour. The paintwork is to be well rubbed down before the last coat is applied.

176. *Ironwork.*—The ironwork is to be cleaned entirely free from rust and to be painted one coat of oxide of iron paint just previous to fixing and two coats of oil colour after fixing. Eaves gutters are to be painted inside and out. Coated soil, vent, and waste pipes are to be once knotted and painted two coats. All iron pipes inside houses not galvanised are to be painted one coat of oxide of iron paint before fixing and one coat of oil colour after fixing, and where exposed distempered or whitened with the walls and ceilings.

177. *Blacking.*—Clean and once black all stoves, range, copper and flue pipe from same, where not galvanised, and clean and polish the bright portions of range.

178. *Internal Woodwork.*—The whole of the internal woodwork usually painted is to be finished in one of the following methods :—(*a*) Treated with one coat of approved wood preserving stain to approved tints. (*b*) The inside of windows and window boards is to be painted three coats of oil colour, as described for external woodwork, and the remaining work treated with one coat of approved wood-preserving stain to approved tints.

179. *External Woodwork.*—The whole of the external woodwork is to be carefully knotted with patent knotting and primed before leaving the joiner's shop, and after fixing stopped with hard stopping and painted three coats of oil colour, including the putties of glazing, except where otherwise described. The feet of rafters and soffit of roof boarding where projecting are to be treated with one coat of wood-preserving stain.

180. *Backs of Window and Door Frames.*—The backs of all window frames and back linings and the backs of external door frames are to be coated with one coat of creosote or other approved material.

181. *Glazing Rebates.*—All glazing rebates are to be primed.

182. *Whitening and Distemper.*—Clear-cole and once whiten all ceilings ; also all friezes above picture rails. All wall surfaces, except in coal store, are to be clear-coled and once distempered with washable distemper of approved tints. The coal store is to be twice lime whited. Any cracks, blisters, or other imperfections in the plaster work are to be cut out, carefully stopped, and made good before any distempering is put in hand.

183. *General.*—Clean down the external faces of buildings, wash off stains, clear off marks of mortar and cement, clean windows inside and outside, scrub pavings and floors, clear away rubbish and waste materials, and leave all parts of the premises clean and perfect at the completion of the work.

HOUSING NOTES.

New Methods of Concrete Construction Approved.

The Ministry of Health has approved of the following new methods of concrete construction. The particulars refer in each case to houses consisting of living-room, scullery, bath-room, and three bedrooms.

Captain Adams, 58a, Warrington Crescent, W.9.—(Adams Building System.)—Hollow steel framework cased in concrete in the walls with concrete slab outer walling and clinker concrete inner walling and partitions. Floors constructed of hollow steel girders and concrete floor slabs. Captain Adams is forming a company with a nominal capital of £200,000, and expects to be able to undertake the construction of a large number of houses, beginning next January. " Rapid construction " is promised.

H. Llewellyn Dent, Ruxley, North Cray, Kent.—(British Craft Homes System.)—Reinforced concrete construction, largely pre-cast with site-moulded elements forming a complete monolithic structure. Mr. Dent has offered to erect two houses for the Ministry's approval at a cost of £350 each on a selected site and afterwards to tender for their erection in large quantities.

Walter Jones & Co., 64, Victoria Street, S.W.—(Clare Interloc System.)—The walls are built with interlocking terracotta blocks 6in. thick and the floors constructed of similar blocks with reinforcing tension rods between the joints. The firm are prepared to build 3,000 houses in a year at an approximate cost of £700 each. The houses would be built in accordance with the Ministry of Health's standard specification except in so far as it is necessary to adapt it to the special method of construction. The estimated price includes everything in the specification, including paths, fencing, and house drainage. The average time of erection and completion is given as four weeks per house.

Dale, Cook & Thornton.—" Dalcot " system of pre-cast tongued and grooved concrete slabs, built as a cavity wall. The wall is strengthened with stanchions formed by interlocking H blocks encasing a reinforced concrete core. The floors and roof are built of timber in the usual manner. Approximate price, £700 ; 500 houses to be built in a year ; time of completion, 10 in 10 weeks for 50 houses per site. The houses would be built in accordance with conditions specified above by Walter Jones & Co.

Dorman, Long & Co.—Houses built up with steel framing covered externally with Hy-Rib metal lathing, thoroughly cased in fine concrete. The steel framing of the walls is completely embedded in concrete to protect the steel from rust. The walls are finished internally with clinker or plaster slabs. Floors are constructed with steel channels, Hy-Rib lathing and concrete floor 3in. thick. Price, £650 to £700; time of completion about six weeks per house. This firm propose to operate through selected contractors, who will submit firm tenders to local authorities. Arrangements have already been made in the Lancashire district.

MODERN BUILDING COMPANY, BRIGHTON.—(Doric System.)—Solid concrete walls filled in between waterproofed asbestos sheets braced together to serve as shuttering during the filling of the wall. Price, £700. Specifications as in case of W. Jones & Co.

HILL, RICHARDS & Co., 16, Albemarle Street, W.1.—("Waller" System.)—The walls are constructed of pre-cast reinforced concrete slabs, 8ft. long by 3ft. wide, forming a cavity wall with site-moulded stanchions, the whole forming a monolithic structure. The floors and roof are constructed in a similar manner, and timber is required only for doors and fittings. Price £815 to £770; output, 250 from any one depot, 4,000 in a year; time, four weeks per house; specifications as in case of W. Jones & Co.

UNIT CONSTRUCTION COMPANY, 246, High Holborn, W.C.1.—Concrete walls built with a continuous cavity and designed so that all component parts are multiples of a given "unit," and ensures that every part fits without cutting. Floors are of reinforced concrete covered with patent composition, floor cover to walls. Price £650; output 3,000 houses in a year; time, six weeks per house; specifications as in case of W. Jones & Co. The company are prepared to erect 10,000 houses. (This system was fully described in our issue for May and November, 1919.)

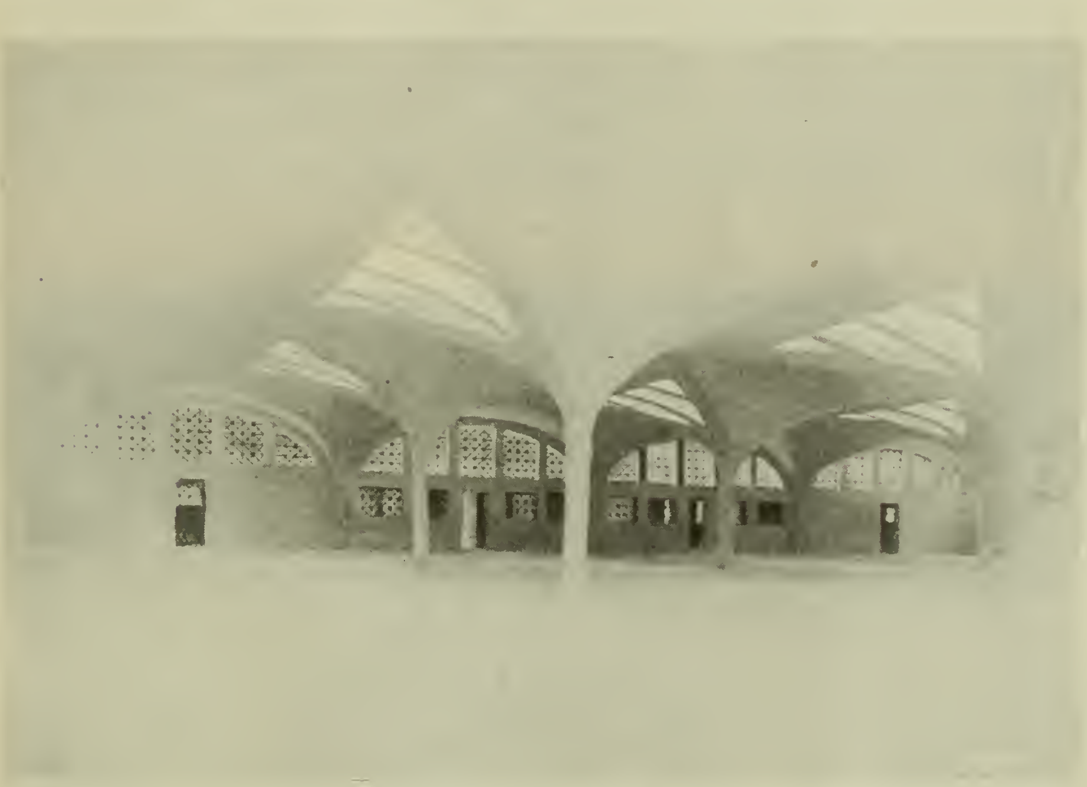
WINGET (LIMITED), 25, Victoria Street, S.W.1.—"Winget" machine-made blocks. Ordinary concrete cavity wall. Price £725. This company is prepared to operate through selected contractors for the erection of houses in large numbers, and would arrange for firm tenders to be submitted to local authorities.

Poured Concrete Houses.—Mr. Charles H. Ingersoll, brother of the well-known watch manufacturer, is now building concrete houses at Union, New Jersey, U.S.A., at a total cost of £440 each, completing each one in a month. Pouring of the concrete takes one day. Three days are allowed for the concrete to set. Sewer pipes and electric light conduits are cemented in the walls. Other plumbing is of the open type. The roof of the house is concrete. The house contains a dining-room, living-room, and kitchen downstairs and two bedrooms and a bathroom upstairs. The mould costs £1,400, but it is claimed that it can be used for 100 houses. Our illustration shows one of these houses in course of erection and another one after completion.

POURED CONCRETE HOUSES IN COURSE OF CONSTRUCTION AND COMPLETED.

THE "ADAMS" SYSTEM OF REINFORCED CONCRETE CONSTRUCTION.

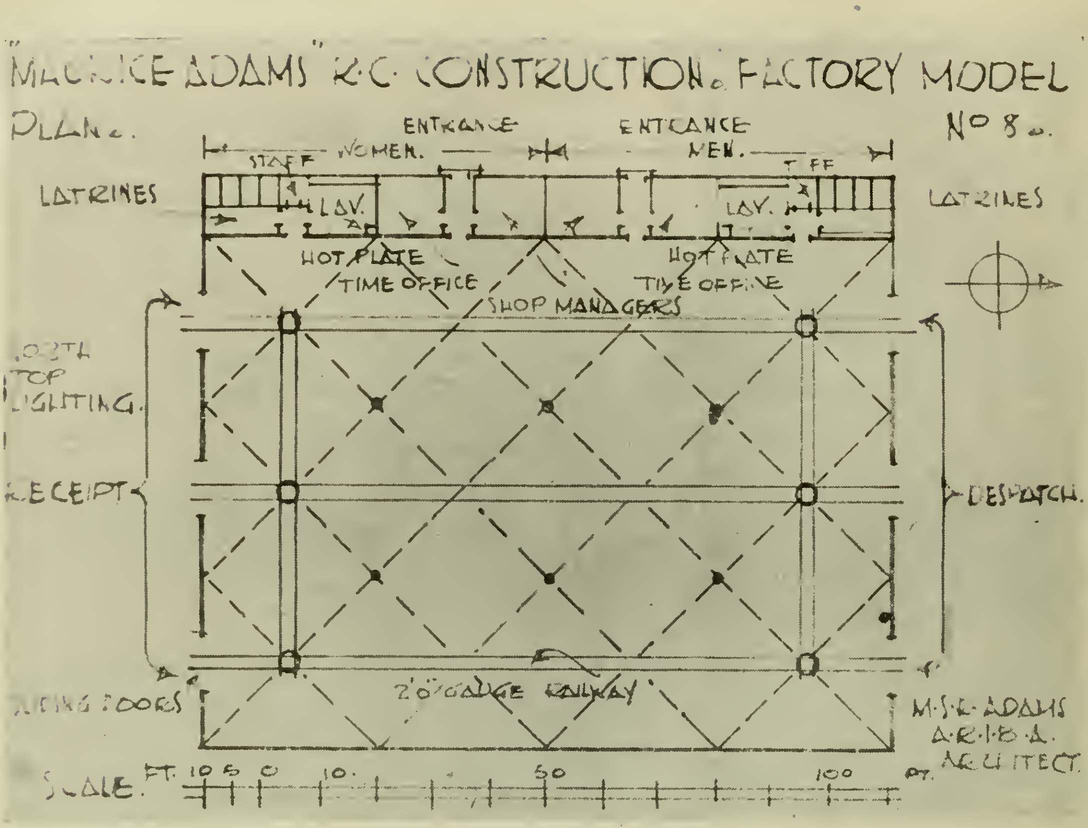
Various new systems of concrete construction are being brought forward at the present time to meet the demand for building large numbers of dwellings rapidly and cheaply.



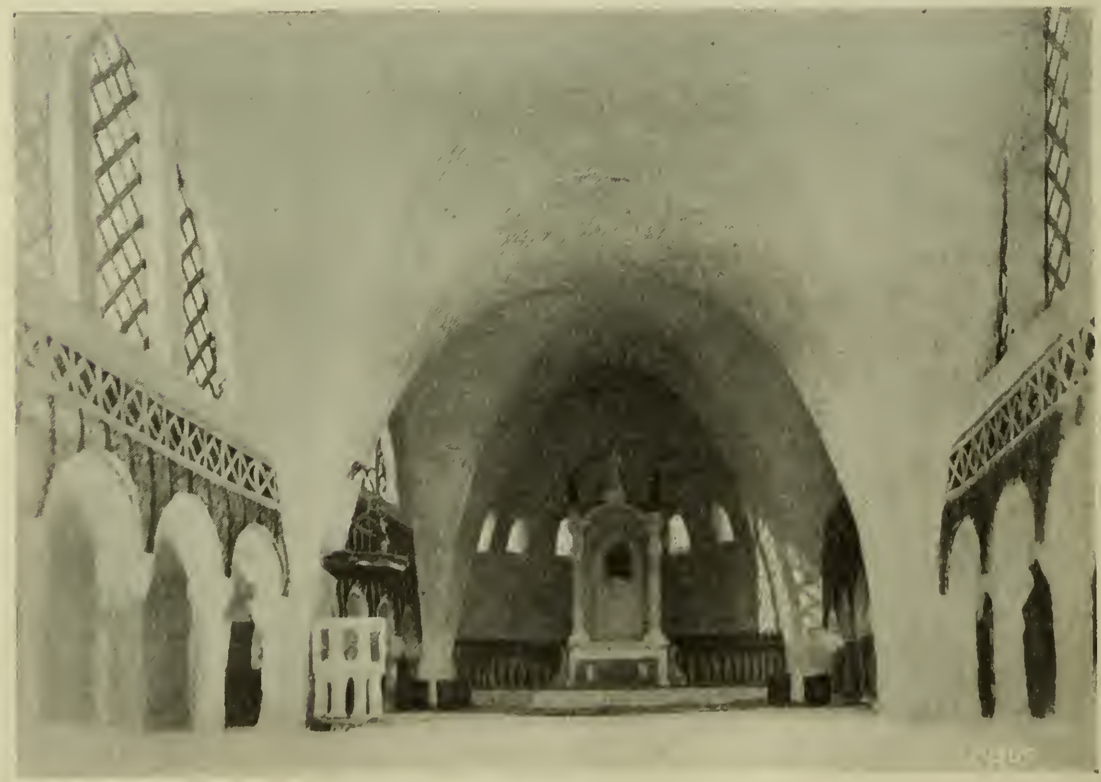
Interior of a Factory Model.

The fundamental idea of the system here under review is the use of elliptical vaulting carried out in reinforced concrete, and the inventor of this system claims that it is suitable not only for buildings of the domestic type, but for churches, schools, halls, cinemas, etc. Briefly stated, the advantages and claims made for the system are as follows :—

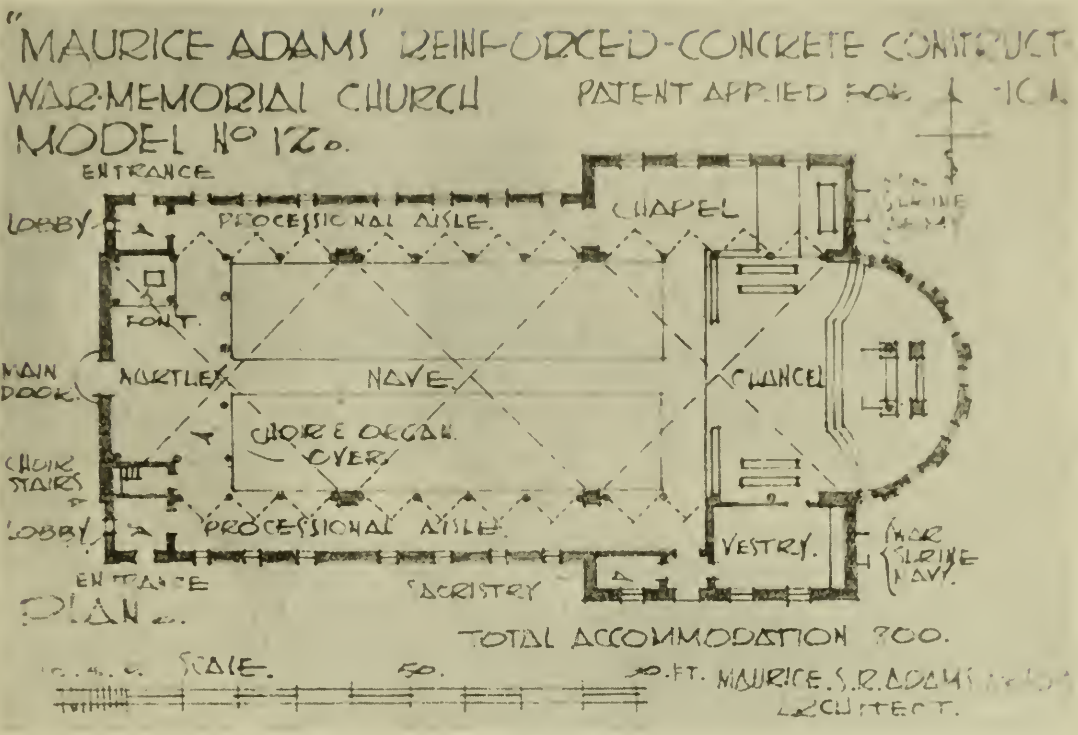
With this method there are no structural walls at all, because the vaults spring directly from the floor level, and thus constitute both wall and roof.



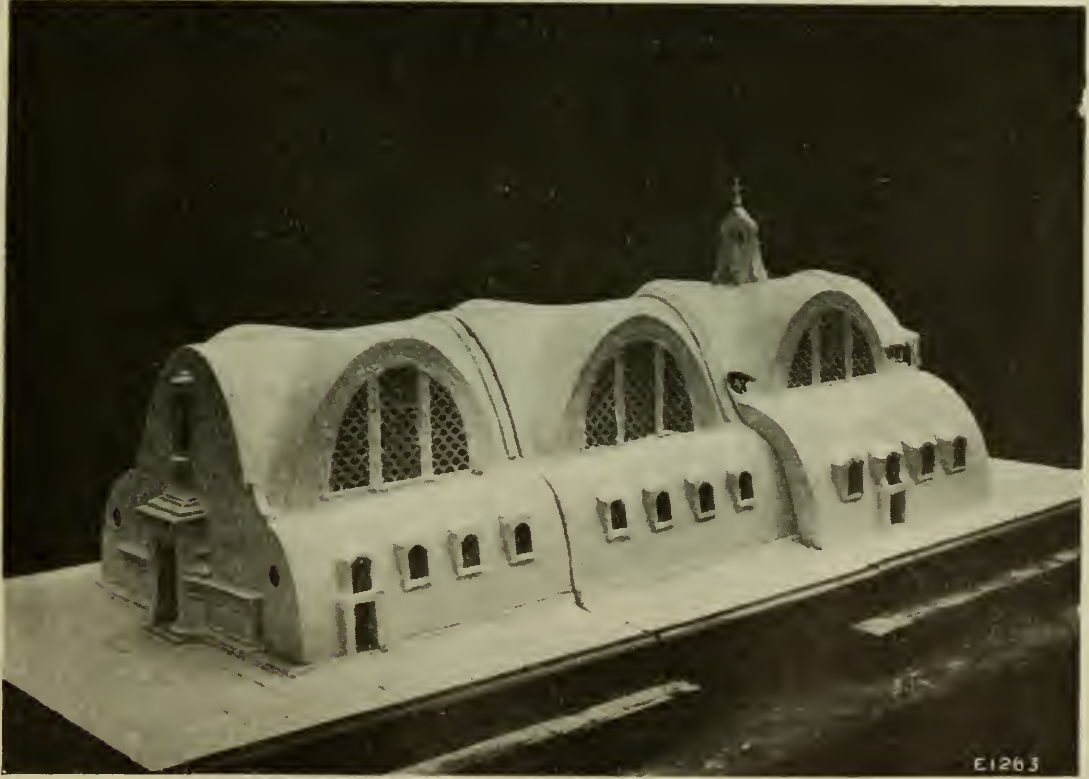
Plan of a Factory Model.



Interior View of a Model of a Church.



Plan of a War Memorial Church.



Exterior View—Model of a War Memorial Church.

The semi-elliptical vaults, being closely allied to parabolic form, possess. for the relative amount of material used, greater strength than is possible by other methods of construction, especially where used in cross form. Buildings roofed with reinforced concrete semi-elliptical vaults a few inches in thickness possess greater strength than buildings designed on orthodox lines for similar purposes and of equal size having walls several feet thick, because such buildings depend on the thickness and not on the form of their walls.

The internal capacity is greater than with ordinary structures, but the total cube and consequent cost is much less, because there are no hidden voids or pockets as in nearly all roofs now commonly employed.

Externally the concrete may be left plain or be faced with brick or stone. and the roofs may be tiled or thatched. For cottage work a good effect can be produced by a thatch covering and whitewashed walls, the chimney stacks being of red brick.

The first building erected on this system is a bungalow at Ruislip. The walls are of hollow concrete blocks, and the roofs of concrete reinforced with self-centering. The self-centering obviates the necessity of wood shuttering. and gives great strength to the finished vaults. As a result of the experiments at Ruislip, the practical details of the system have been improved, resulting in economy of both time, material and cost.

It is claimed that bungalows on this system may be erected for half the cost of brick building and in half the time. A number of bungalows on the improved system are now in course of erection at Herne Bay, and arrangements are in hand for a large number of other buildings.

MEMORANDUM.

Concrete Cottages.—The Brighton Town Council has accepted the tender of the National Improved Housing Co., Ltd., of 26, Victoria Street, S.W., for the erection of twenty concrete houses on the "Condual" system. Fourteen of the houses will have flat roofs, and cost £798 19s. each, and the remaining six will have sloping roofs, and cost £851 7s. each. The firm is also erecting 150 concrete houses on the same system at Porthcawl. The foundation stone was laid last month, and it was expected that the houses would be ready for occupation in less than a month.

The Housing Committee of the Birmingham City Council have decided to erect concrete houses, and orders for 23 of this type of dwelling have been placed.

Negotiations are also proceeding for the erection of a further 100 houses in concrete, but the site has not yet been definitely fixed.

A tender has been accepted for the erection of 20 concrete houses at Wolverhampton, and it is stated other authorities in the Midlands may also proceed with the erection of similarly built dwellings.

BETTERING CONCRETE BY A NEW MIXING METHOD.

By NATHAN C. JOHNSON.

The first part of this article appeared in our October issue.—ED.

(Concluded.)

II.

Starting experimentally with studies of the chemical union of cement and water, it is found that the process is initially of much greater rapidity at elevated temperatures. In *Fig.* 4., for instance, are shown interlacing crystal formations at 70° F. after three hours, as contrasted with those at 50° F. after 10 hours. As the latter photographs show no visible change from their original appearance, temperature is evidently of great assistance in forming concentrated products.

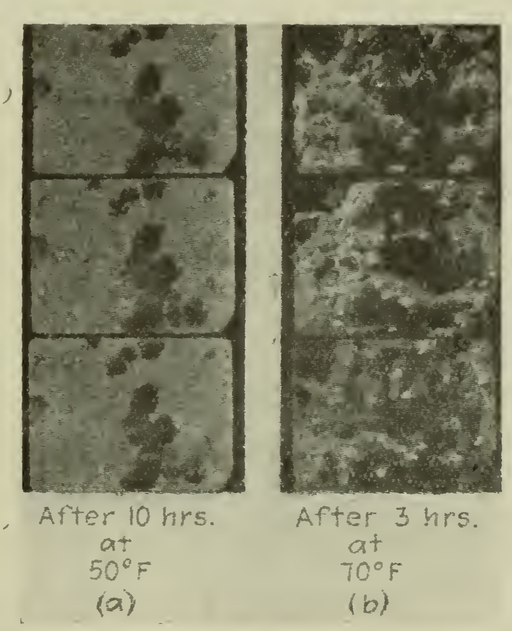

After 10 hrs. at 50°F (a)
After 3 hrs. at 70°F (b)

Fig. 4. Hydration of Portland Cement; Camera intervals, 5 minutes.
Grouping of cement particles rendering futile fine grinding.

It is further to be noted from these photographs that there is grouping together of individual particles, with less intense formation of cementing products at the boundaries of such groups than at single particles. If such grouping were to exist in concrete, much of the cement would be taken from points where it should be usefully applied, since hydration would soon begin to act to unite these groups inseparably. But since these groupings are always observed, such derivation doubtless does take place, with resultant effect on the concrete. Furthermore, examination of commercial powdered cement reveals small aggregations present in infinite number, due possibly to hydration from moist air and sticking together before it reaches a user's hands. Evidently such groupings should be forcibly broken up either prior to or during mixing, and evidently, also, there is little use in finer grinding of cement unless such groups can be broken up.

In addition to elevation of temperature, it is also found that intensive hydration can be brought about by violently stirring cement for periods longer than are usually employed, much as stirring sugar increases the sweetness of a cup of coffee. And it is further found that while sand grains poured into water are lifted bodily by tenacious air bells resident at irregularities in their surfaces, such air bells can be removed and full contacting of water (or of cementing solutions) brought about not by stirring alone, but by such violent stirring as to cause the attrition of particle on particle sufficient to bring about a scrubbing action. Considering these two phenomena in analogy, it is not improbable that the increased hydration of cement brought about by violent stirring is due to a removal of the protective skin from individual particles through such inter-particle attrition, bringing about earlier and more prolonged chemical activity, as well as through the forcible breaking up of minute groupings before noted.

Combining these two benefits of removal of tenacious impurities and increased hydration by violently stirring cement and sand together in water, there is every element present of an improved process of making concrete, particularly as such violent stirring raises by internal friction the temperature of the mass, with further increase of hydration.

But what is the actual effect and result of this as expressed in accomplishment ? Aside from increased hydration products as noted by the microscope, there is formed a viscous, coherent mixture, not inclined to separate even though very plastic, with little or no formation at the surface of fluffy "laitance." Remembering the levitation of sand grains in water by attached air bubbles, as well as the lubricative effect due to the mobility of gaseous bubbles in a liquid, it is not improbable that removal of such bubbles, together with the heavier specific gravity of the fluid brought about through increased solution of cement, has overcome the tendency to segregation usually present. Furthermore, it is at once evident that if increase of hydration can be assured, greater tolerance in the percentage presence of water is permissible, with increase of plasticity and ease of working, and at the same time, assurance of a satisfactory result. Elimination of laitance and segregation on commercial operations would be of utmost importance, for materials so separated are almost valueless of themselves but would have high value if retained in their proper places.

And a corollary effect should be better compacting and greater solidity of the mass, with commensurate strength and endurance. If the particles shown in *Fig.* 2 had been closer together, solutions of cementing products at the surfaces of sand grains would have been stronger, through nearness to the source.

Furthermore, a greater number of strong sand grains would have been present in any given volume. This result is sought in commercial work by spading, tamping or rolling, the last named being found by study to be preferable where

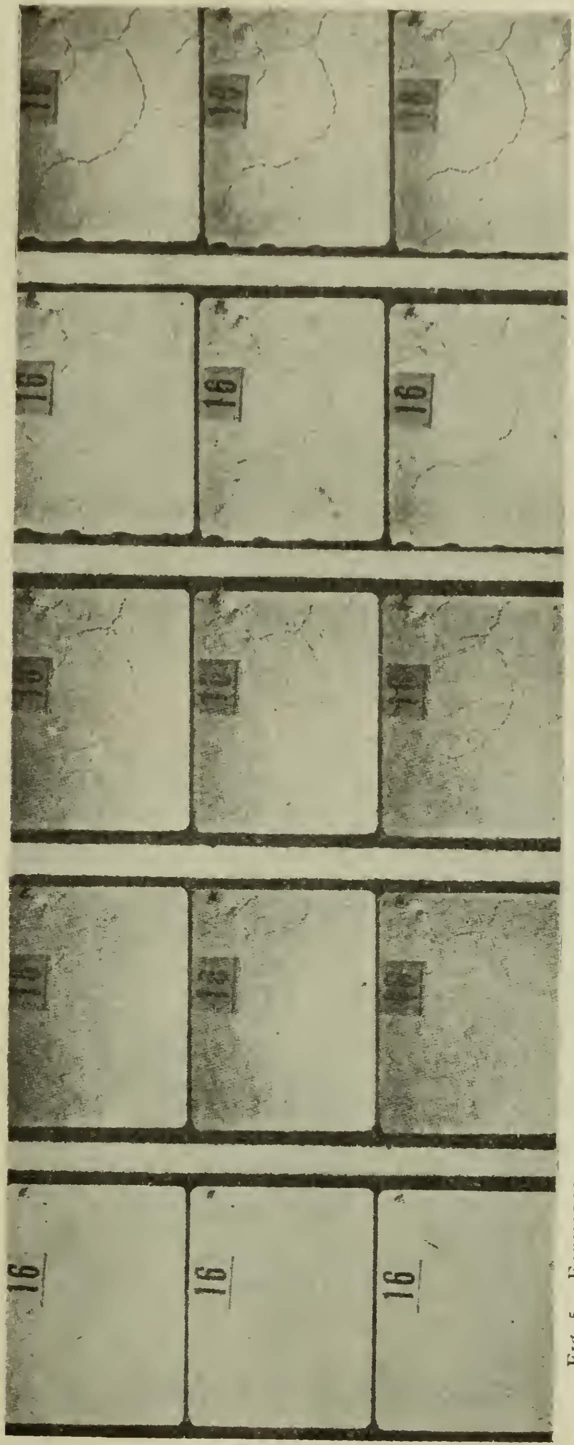


Fig. 5. FORMATION OF THREE-BRANCHED CRACKS IN STUCCO CAUGHT BY CINEMATOGRAPH CAMERA AT ONE-SECOND INTERVALS
Note that these originate at the surface pit seen in the upper right-right corner

the form of construction, as in roadways, permits of its use. Yet, if increased hydration is realised, together with very thorough distribution of such hydration products and detachment of air bubbles from sand and stone, a minimum of such artificial compacting is found to be necessary for a substantial improvement in texture and strength.

Furthermore, there should be less likelihood of points of weakness developing in such a product, either through the presence of an impurity at a centre of disintegration or through loss of uncharged water, or through unequal internal strain due to non-uniformity. Study confirms this reasoning, for mortars (stuccos) and concretes reveal that three-branched cracks and their later ramifications are of primary origin, occurring at or about the time of set ; and that they are induced by lack of uniform internal strength, for rupture comes suddenly, much as a sheet of paper might find relief from unbearable strain by rupturing abruptly about some point of weakness. (See *Fig.* 5.)

And, not least, disintegrations and softenings should, with such material, be at least mitigated, if not fully done away with. Disintegrations result from entrance of water into the body of concrete. Sea water carries so little material capable of attacking concrete that the entrance of many millions of gallons into the concrete is necessary for effective attack on a single cubic yard. Nor is the action of fresh water substantially different ; and with this fluid the same requirement applies. As for rupture by rusting of reinforcement, the existence of this fault argues conclusively that water has reached the steel through the concrete, but when that happens, rusting, with expansion and rupture, is to be expected. On the other hand, given a uniform, dense concrete, without water or air voids, or laitance seams, or shrinkage cracks, the seas and lakes and rivers must confine their efforts to surfaces, instead of finding ready access to the interior, with proportionate endurance.

But however much laboratory experimentation may prove, conversion into commercial terms only will be of substantial benefit.

Early in this effort, existing forms of mixers were discarded as ineffective and not susceptible of necessary changes. With time ever a limitation, the first thought was to substitute rapidity of action for customary slowness. ·By the same agency, also, it was hoped to effect the violence that seemed to be necessary to force reluctant materials into proper usefulness. In addition to rapidity of action, repetitive cycles and a mass held compactly together to secure interparticle attrition were indicated. These constituted a new and different process from that heretofore used and demanded new means to effect it.

High rotative speeds imply centrifugal force as a concomitant. Centrifugal force would hold the mass of materials together, but would render inactive the usual drum mixer. Furthermore, a very small portion of available drum space in such machines is in active use, the overcapacity varying from 250 to 825 per cent. of the batch size in the products of 10 different manufacturers. It was also found that much useful mixing time was consumed in charging and discharging, batches having to enter and leave through severely constricted openings.

The expedient was adopted, therefore, of using an open bowl, rotated rather rapidly in a vertical axis. Centrifugal force would compact the rotating batch in the bowl and cause it to rise toward the top. At proper points, curved blades could cut off ribbons of material, diverting them to the centre, so that repetitive cycles could be brought about. Discharge could be overside by utilising the

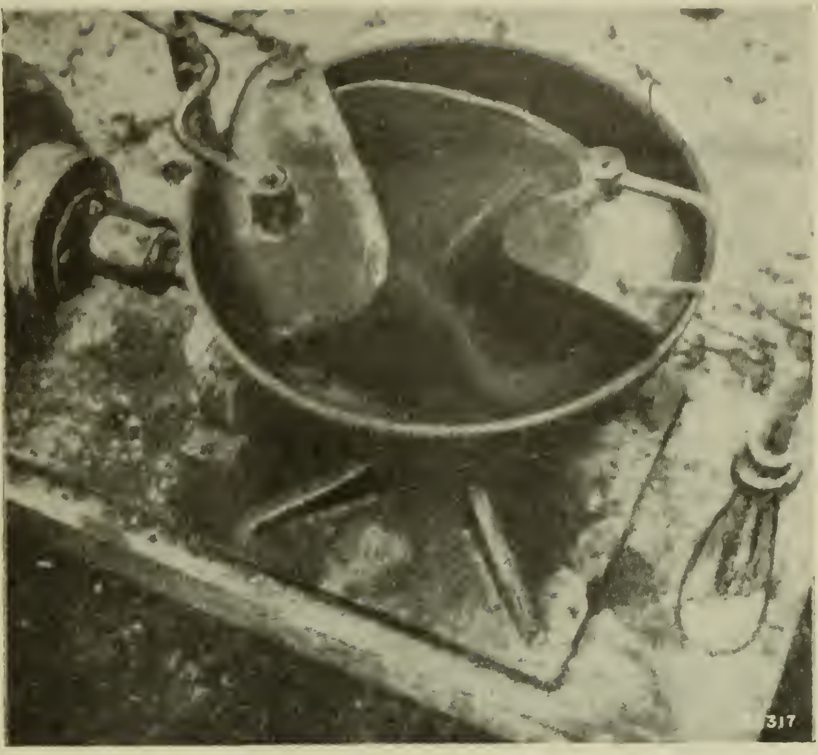


FIG. 6. FIRST CENTRIFUGAL CONCRETE-MIXING MACHINE IN ACTION, 10-IN. DIAMETER BOWL.

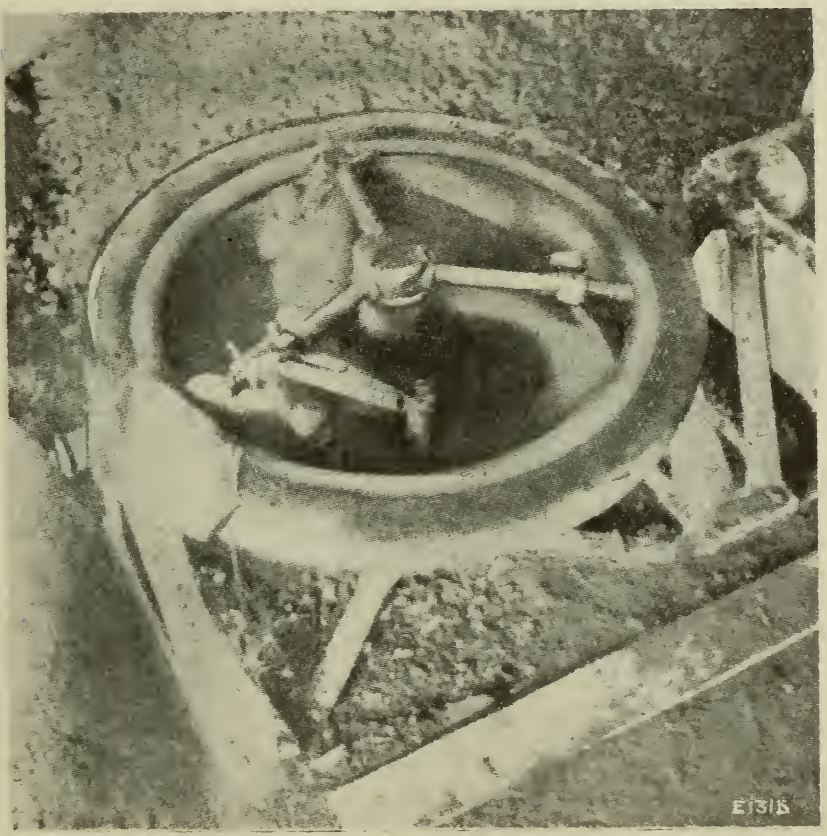


FIG. 7. THREE-CUBIC-FEET CENTRIFUGAL MIXER IN ACTION.

velocity of the mass, giving a high discharge, while the full diameter of the bowl would be available for charging, doing away with the high elevation of material necessary to make it pass through a constricted spout. Furthermore, both mechanism and mass would be open at all times to observation.

The first mixer held 30 lb. of material and was improvised from an iron potato kettle with an iron tamper for a base, the bowl being rotated through one set of gears by a $\frac{1}{8}$ h.p. motor which once operated an adding machine. (See *Fig.* 6.) Diverting blades supported by small pedestals overside completed the mechanism. Strangely enough, it was successful almost from the first; and results obtained with it were so interesting that larger units were undertaken. A 3-c. ft. machine was then constructed (*Fig.* 7) and later a $\frac{1}{2}$-yd. machine. Trials and tribulations were not few in number, but they are of no import in this discussion. Suffice it to say that a most intense action was secured, showing in practical result the actuality of the theoretical needs indicated by the reasoning before set forth.

MEMORANDUM

Concrete Aggregates.—A very useful piece of work undertaken by the Concrete Institute is the collection and tabulation of information on the aggregates available for concrete work in different districts of the United Kingdom.

A standard form has been prepared and circulated to county surveyors and others, designed to show succinctly the important characteristics of the aggregates in their districts, and we understand that there is now available for reference at the offices of the Institute a large volume of information which should be of the greatest value to all who contemplate concrete work.

The form of return is illustrated herewith, and from this will appear the type of information now for the first time made available for reference :—

PARTICULARS OF AGGREGATE AVAILABLE FOR CONCRETE WORK.

Date.......................... *District*....................

(1) General description .. ..
(2) Source and locality of same .. ..
(3) How obtained .. ..
(4) From whom obtained .. .. ..
(5) Is available quantity limited ? If so, how ?
(6) Present maximum output per day (stated in cu. yds.) .. ..
(7) Transport facilities .. ..
(8) Is there any provision at or near source for washing or crushing ? .. .. ..
(9) Price per cu. yd., and where delivered ..
(10) Is composition uniform ? .. .. ..
(11) Detailed description :—
  (*a*) Kind of stone or coarse material ..
  (*b*) Kind of sand or fine material ..
  (*c*) Relative proportions of coarse and fine material .. ..
  (*d*) Shape of particles (rounded, angular, flat, etc.) .. ..
  (*e*) Size of particles ; approximate percentage, that needs crushing, to pass $\frac{3}{4}$ in. screen .. ..
  (*f*) Impurities present (as clay, sulphur, coal, organic matter) .. .. ..
(12) Source of information .. ..
(13) Is sample sent with this sheet ? .. ..
(14) General remarks .. ..

If possible the following information should also be supplied and in accordance wth the Concrete Institute Programme :

(15) Specific gravity .. ..
(16) Weight per cu. ft., dry .. .. ..
(17) Proportion of voids .. ..
(18) Granular analysis .. ..
(19) Crushing strength of stone .. .. ..
(20) Absorption of stone, as % by weight ..
(21) Proportion of muddy matter .. ..
(22) Percentage of loss of weight by attrition (National Physical Lab.—Road Board Test) .. ..

Members of the Institute will be at liberty to refer to the returns during ordinary office hours without charge, but others will have to pay a small search fee. Copies of any particular forms will also be provided for either members or non-members at a small covering charge.

CONCRETE TRACK SUPPORTS.

(Concluded.)

By A. C. IRWIN, Portland Cement Association.

The following is a report presented at the last Convention of the American Concrete Institute, and deals with some interesting problems bearing on the economy in maintenance costs on American railways.—ED.

In 1911, 500 ft. of concrete track support was installed by the Chicago Junction Railway over the crossing of the Illinois and Michigan Canal. The details of this type are shown in *Fig.* 8, and a view of the completed track in *Fig.* 9. This construction

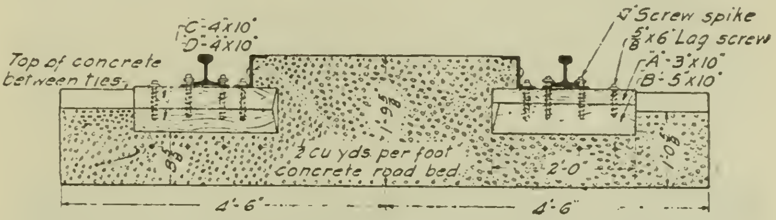


Fig. 8. Details of Concrete Track Construction on Crossing Chicago Junction Railway.

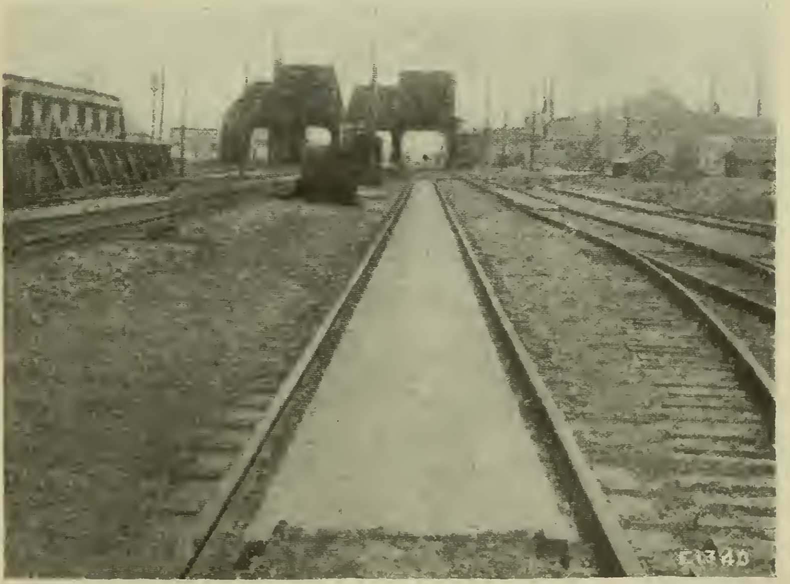
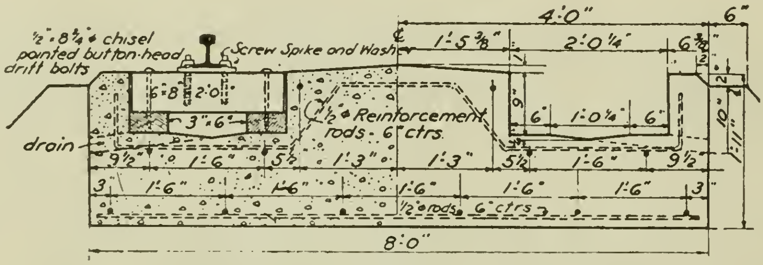
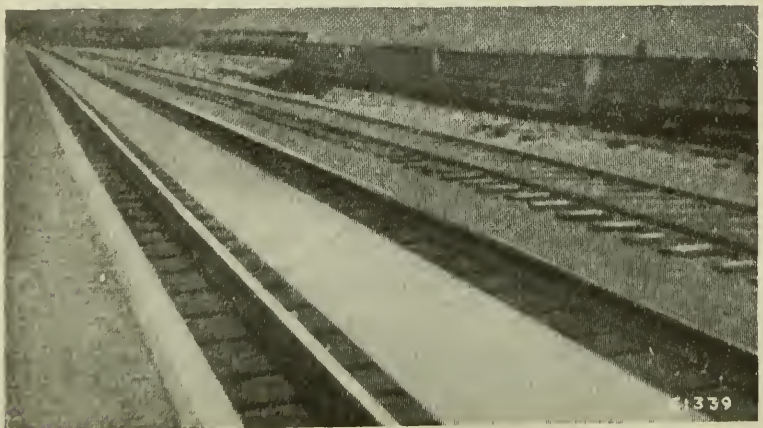


Fig. 9. View of Concrete Road-bed at Crossing on Chicago Junction Railway.

was installed on the Chicago Junction Railway as an experimental stretch of track, the location being selected with a view to subjecting it to very heavy and continuous traffic. A majority of the stock trains going to the Chicago Stock Yards pass over this concrete track. These trains are usually drawn by heavy locomotives and make more than usual freight train speed. A thorough examination of the track indicates that although transverse cracks appear in the portion of the concrete above the base of rails, these cracks do not extend down into the supporting slab. In fact, the construction seems to have suffered practically not at all from the heavy traffic which it has carried. The chief engineer of the Chicago Junction Railway states that there has been no maintenance on this stretch of track excepting to renew a few of the tie blocks. The latter are spaced 34 in. centres. So great a spacing would not be allowed with the usual ballast and tie type of construction but with this unyielding track foundation the larger spacing has been found to be practicable, since the greater part of the deflection in railroad track is due not to the lack of rail stiffness, but rather to the lack of any sort of rigid support. Further claims made for this type are: weight of train distributed over three times the surface; it saves ·6 of the ties; the cost of 20 years is one quarter that of a rock ballasted track.



TYPE 1

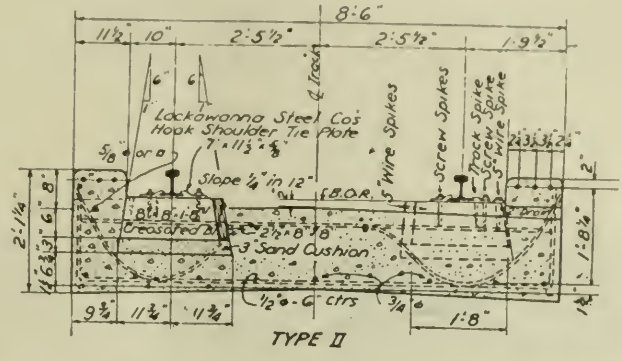


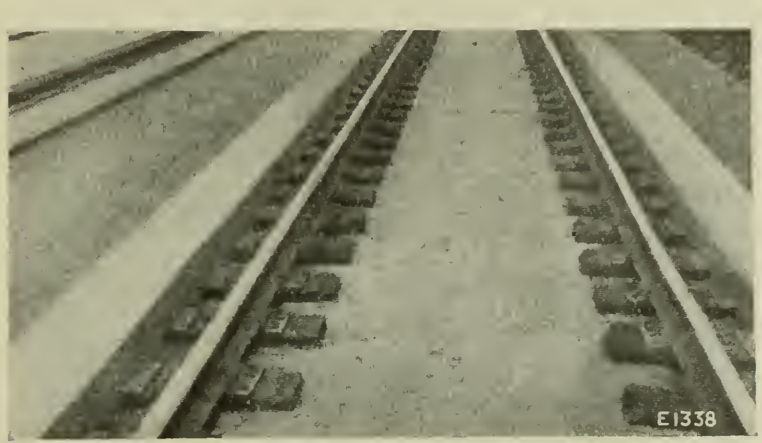
Figs. 10 and 11. Details of Support and Views of Type 1 Concrete Track of completed Roadway on Northern Pacific Railroad.

SLAB FOUNDATION.

The third class of track support is utilised on the Point Defiance Line of the Northern Pacific Railway in the State of Washington. About 2,000 ft. of track with a concrete slab foundation were constructed about five years ago. Details of the three types used and the actual appearances of the roads are shown in *Figs.* 10-15. In general these types consist of a reinforced concrete slab provided with recesses or troughs for the reception of wood blocks or stringers to carry the rails. In the first type, *Fig.* 10, the short tie blocks rest on two longitudinal 3 in. by 6 in. pieces in the bottom of a trough at each side of the slab, and the space between the tie blocks is filled with ballast. A total of 594 ft. of this type of construction has been in use. The slabs are cast in lengths 16 ft. 5½ in. and drainage of the troughs is provided at intervals.

Type No. 2, *Fig.* 12, is 6 in. wider than type No. 1 or No. 3, and is distinguished by a curb practically equal to the height of rail along each side. There are also





Figs. 12 and 13. Details and View of Type 2 Track, Northern Pacific Railroad.

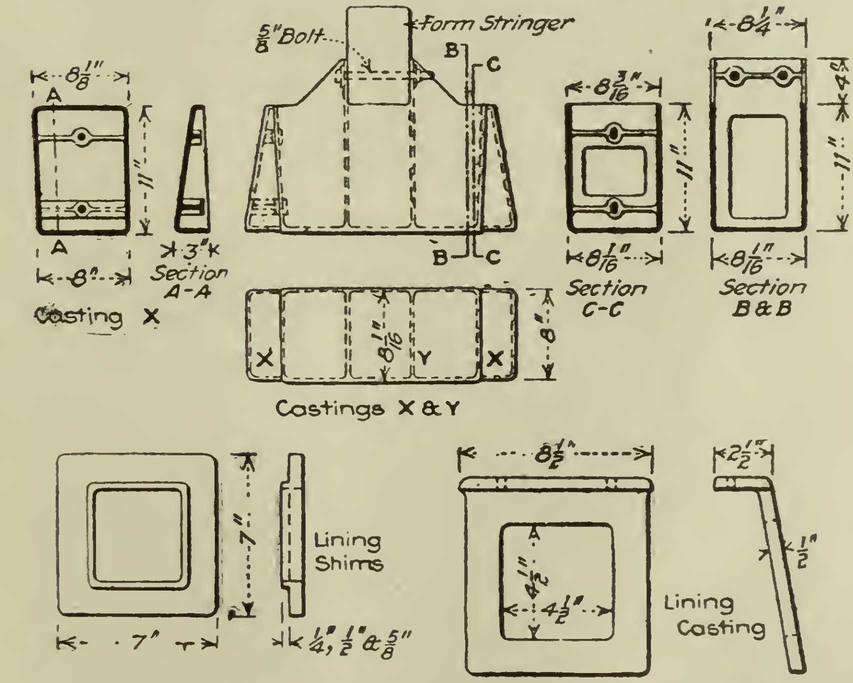


Fig. 14. Iron Forms for Pockets in Slab and Iron Shims for Rail Blocks. Type 2.

594 ft. of single track of this type in service. In this type, recesses are cast into the slab into which the tie blocks are placed and wedged into position. The rails are fastened in the usual way with tie plates and screw spikes. In the bottoms of the tie block recesses, 3 in. of sand are placed to afford a cushion. On top of this sand cushion the creosoted tie block is placed and wedged at the inner end of the block. L-shaped malleable iron shims are used at the other end of the tie blocks, with one leg of the L resting on top and fastened to the tie block. This allows lining and gauging of track. These slabs are cast in widths of 32 ft. 11 in. The forms for Type 2 are shown in *Fig.* 14*a*.

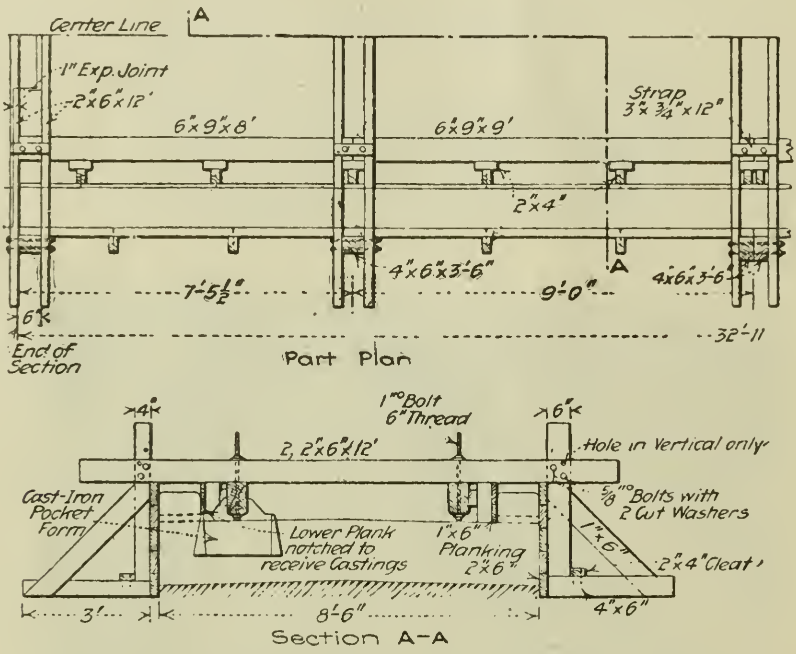


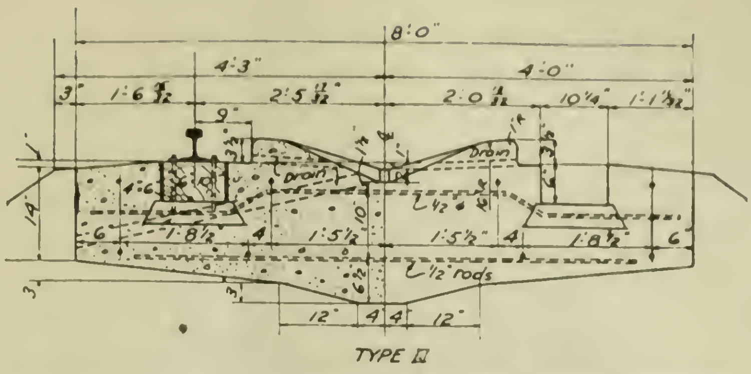
Fig. 14a. Forms for Slab. Type 2.

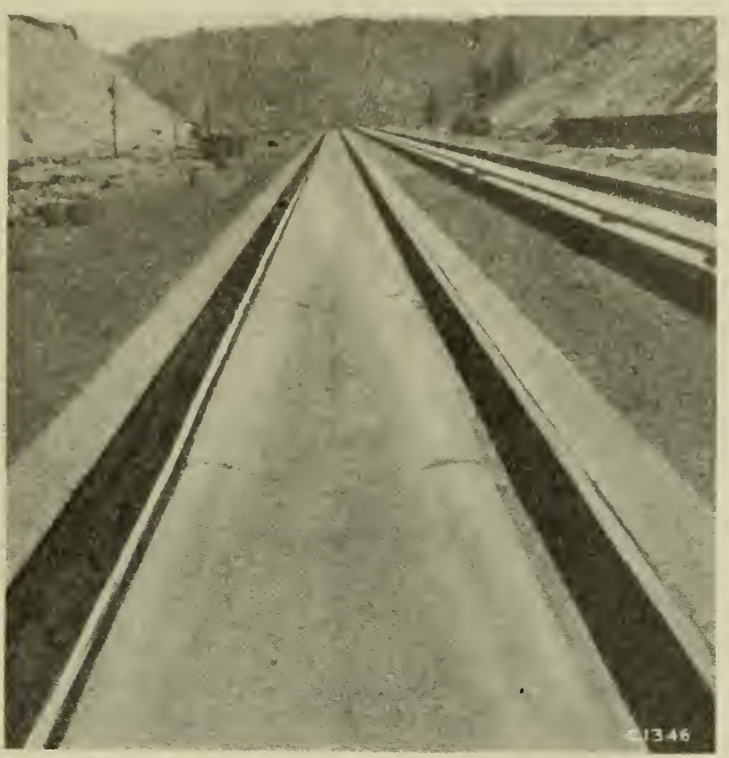
The third type is shown in detail on *Fig.* 15. The distinguishing features of this type are that the concrete is carried up $3\frac{1}{2}$ in. near the inside of each rail and sloped to centre of track for drainage and that the rail rests directly on a continuous longitudinal stringer of 6 in. by 10 in. creosoted fir. These stringers are fastened at intervals by long lag screws driven into wood anchor blocks embedded in the slab. The slabs have a depth of 18 in. at the centre and were moulded in lengths of 16 ft. $5\frac{1}{2}$ in. There is a total of 810 ft. of single track of Type 3. *Fig.* 16 shows the appearance of this track in service.

While neither the first cost of the concrete track foundation on the Northern Pacific Railroad, nor the annual maintenance cost are available, the railroad company's officials say that the maintenance has been far below that of track of the ordinary type of construction on the same line. The greater part of this maintenance concerns the wooden blocks to which the rails are fastened especially with Type 2. In this type the key blocks come out in spite of the fact that they are spiked to the tie blocks.

NEW PROPOSED TYPE.

A suggested design for a concrete track support as prepared by A. D. Whipple and the writer is illustrated in *Fig.* 18. The form work required for this slab is of the simplest sort. The design of the slab is based on Cooper's E-60 leading with 100 per cent. impact. This design does not require any radical departure from the usual type of rail fastenings, that is, a rail clip is used similar to those now standard. There is, however, a very great difference between this rail fastening and the usual cut or screw-spike used with wooden ties. In this concrete design a U-shaped casting is embedded





Figs. 15 and 16. Details of Type 3 Concrete Track Support and Views of completed Roadway on Northern Pacific Railroad.

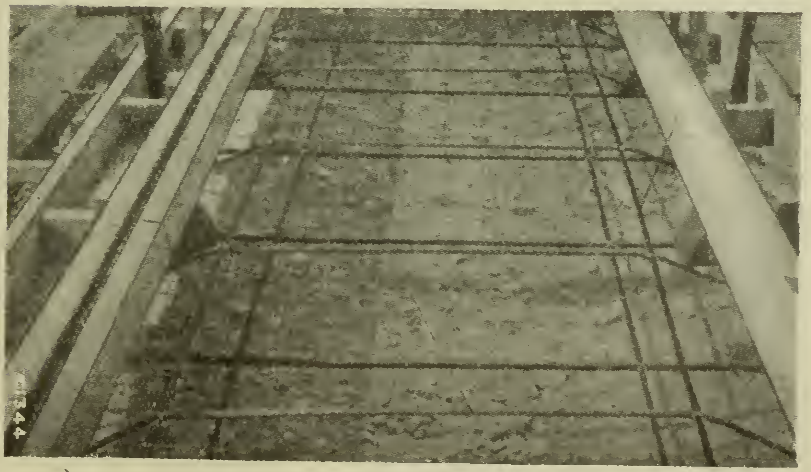


Fig. 17. Form Work and Float Finish for Roadway, Northern Pacific Railroad.

in the concrete and the up-standing legs of the U are tapped to receive the threaded end of holding down bolts which pass through the rail clips, tie plate and tie block. A positive fastening which has great strength against lifting the rail is thus secured. The use of a block of wood under the rail in this is also a concession to the idea that some elastic medium must always intervene between a track rail and a solid foundation and a means for easy adjustment of the rail both vertically and horizontally to provide for whatever inequalities may exist in the top of the slab either at the time of placing or subsequent thereto. The latter is the only sufficient reason for using this tie block, and where the slab is placed on well compacted subgrade the rail may be anchored directly to the concrete, with possibly the intervention of a longitudinal steel plate between the rail and the concrete surface, thus affording the rail a continuous support. In this case drainage would be taken care of by finishing the slab to a slight pitch between the rails and furnishing openings beneath the rails at intervals

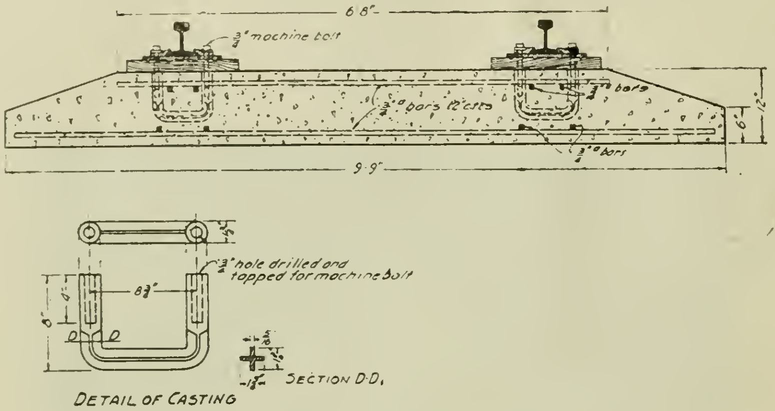


Fig. 18. Design of proposed Concrete Track Support

ECONOMIC CONSIDERATIONS.

In the final analysis, the use of concrete track construction will be governed by economic factors. Will it pay? Will the economies and advantages derived from it afford an adequate return on the cost of installing it? The answer to this, in so far as the writer has been able to determine, is very positively yes. Every estimate that has been made by those who have investigated this subject shows even the "visible" income entirely sufficient to warrant the extra expenditure necessary to place such construction under heavy traffic track either on new construction or on existing lines.

In 1899 it was estimated that the construction shown in *Fig.* 5 would effect a saving in maintenance and renewals of an amount sufficient to pay 8·8 per cent. on the added investment each year. If we credit this estimate with the cost of the 12 inches of useless stone under the concrete slab we would have a yearly income of 11·7 per cent. on the extra cost. For the design shown in *Fig.* 1, involving longitudinal stringers under each rail it was estimated that the saving on ties alone would pay 3 per cent. on the extra cost of the concrete construction and that therefore the saving in maintenance and renewals of the track other than the ties would be net. Likewise, annual maintenance and renewal costs for a track, as in *Fig.* 6, show an earning on the extra cost of concrete slab construction of *over* 40 *per cent. per year*, due to savings in maintenance and renewals.

L. V. Morris, chief engineer of the Long Island Railroad, said in regard to an adaptation of the design shown on *Fig.* 3 to main line service:

"In constructing a new line I cannot conceive that the cost would be over $2 per running foot, single track, for a slab 10 ft. wide and 8 in. thick. This would be in the neighbourhood of $10,000 per mile, and is a very small part of the total cost of a modern roadbed, such as I have in mind, running anywhere from $100,000 to $200,000 per mile, single track. It seems to me that this expense is justified, particularly as it supports practically the only working part of the roadbed. This working part, namely, track, is the most expensive to maintain, and upon its condition depends largely wear and tear of the rolling equipment."

Estimates prepared with all possible care on the design presented in *Fig.* 18 showed an income derived from reduced maintenance and renewals on the concrete type of 18 per cent. on the extra cost of construction of new double track and 12·72 per cent. on the cost of placing the slab under existing lines. Neither these figures nor any of those referred to, excepting those of Mr. Schaub, give any credit for saving in motive power due to absence of rail deflection or the reduced maintenance on equipment. This has been shown to be exceedingly large, and therefore the extra saving in costs must be considered in investigating the question of track support.

It is not to be expected that the proposed type of concrete construction would be economical on any but heavy traffic track, but for such track there is a crying need for it. The present general type will, doubtless, survive on other than the most important lines, but for heavy traffic track there seems to be no other reason why concrete support is not more extensively used than the possible difficulty in financing the first cost. However, such financing should present no unsurmountable obstacle in view of the promising economies and advantages to be derived from the closer approach to ideal track conditions afforded by a strong, permanent non-deflecting concrete track support.

MEMORANDUM.

The Heat-Insulating Properties of Concrete.—The United States Bureau of Standards has recently undertaken an investigation into the relative efficiencies of materials commonly used in fire-resistive construction to protect load-bearing members from the heat of an accidental fire. All the materials were made up into specimens in the form of solid cylinders, 8 in. in diameter and 16 in. in length. The tests were made in a gas-fired furnace of special design, the temperature of which was gradually raised to 927° C. in 90 minutes, and held at approximately that point for about two hours. Concretes made from two mixes, 1 : 2 : 4 and 1 : 3 : 6, and with a number of coarse aggregates were included in the investigations, and it was found that concretes with a coarse aggregate of gravel and those from bituminous cinders containing a large proportion of combustible material heated through most rapidly. Mixtures made with clean bituminous cinders, trap rock and blast furnace slag heated through more slowly, while those made with limestone heated through somewhat more slowly than any of the others. It is stated that the less rapid temperature progress in the limestone concrete specimens may be attributed to the heat absorbed by the decarbonisation of the limestone in a thin layer of concrete next to the exposed surface, and to the fact that the resulting calcium oxide was presumably a better heat insulator than the original stone. All the concretes were weak after the test. Limestone concretes retained more strength than those from other coarse aggregates, although the cinder concretes were tougher than the others. The weakest of all after test were the gravel concretes; this is largely attributed to the fact that the gravel was made up of quartz and quartzose materials, as it is known that the expansion behaviour of quartz, including the sudden volume increase as the inversion point, at 575° C., is approached, is specially conducive to destructive strains.

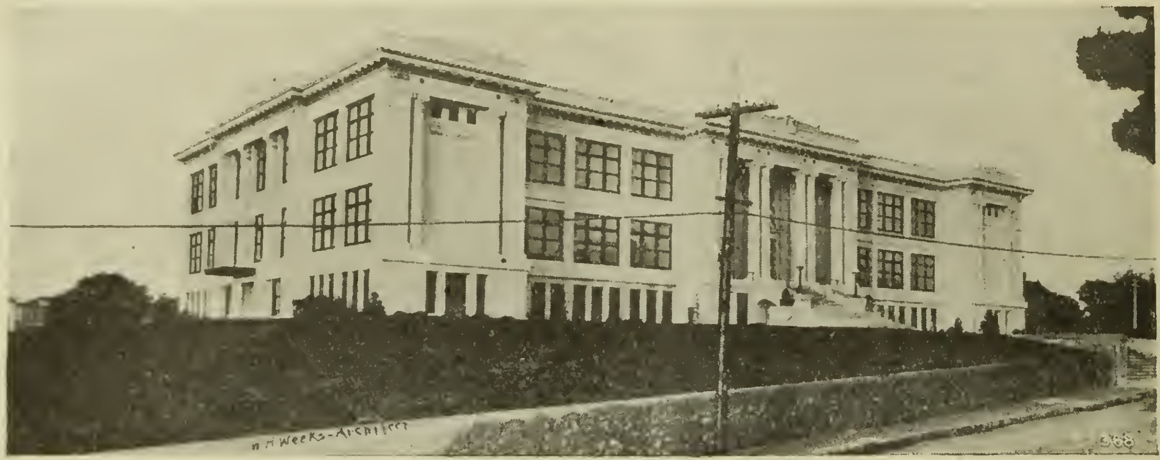


Fig. 1. High School, Santa Cruz, California.

SOME CONCRETE SCHOOL BUILDINGS IN CALIFORNIA.

The following illustrations are interesting examples of the use of concrete in California for the purpose of school buildings. The structures shown are all of reinforced concrete and in nearly every instance the ornamental work indicated is of artificial stone. For our information and illustrations we are indebted to Mr. William E. Weeks, architect, San Francisco, who is the designer of the buildings in question and under whose supervision they have been erected.

This type of building has proved very satisfactory on the Pacific coast, and some very beautiful effects have been obtained by the use of colours. Furthermore, reinforced concrete buildings have been found to afford greater resistance to the earthquake shocks to which this coast is subject.

An interesting feature of the Healdsburg and Watsonville High Schools is the use of ramps instead of stairways. Careful study has revealed that these ramps have the following advantages : there is very much less effort required in ascending an incline of this grade than exerted in climbing the regulation stairs, and both teachers and pupils prefer them. One of the strongest arguments in their favour is that they eliminate the danger of stumbling almost entirely ; stumbling on stairways is one of the things that has cost considerable loss of life during fire panics in some of the American schools. This feeling of security from danger constitutes the strongest appeal to those who have considered their use, and it is not associated with the average stairway. The ramps have a grade of 2 in. to the foot, and the architect has used them in two slopes and three slopes, according to the plan of the building. The floors of the concrete inclines and main corridors in the buildings illustrated are covered with cork carpet, which reduces the danger of slipping to a minimum, and makes them almost noiseless.

The buildings are so planned that the minute the pupil steps out of a classroom door, he is in a fire-resisting passage leading to the outside of the building. The auditorium walls, corridor walls, inclosing walls of inclines, and principal cross walls are all of reinforced concrete, while the boiler rooms and chemical laboratory are entirely fire-resisting. All corridor floors and floors of ramps and stairways are of reinforced concrete. All stairway treads are provided with patent safety treads.

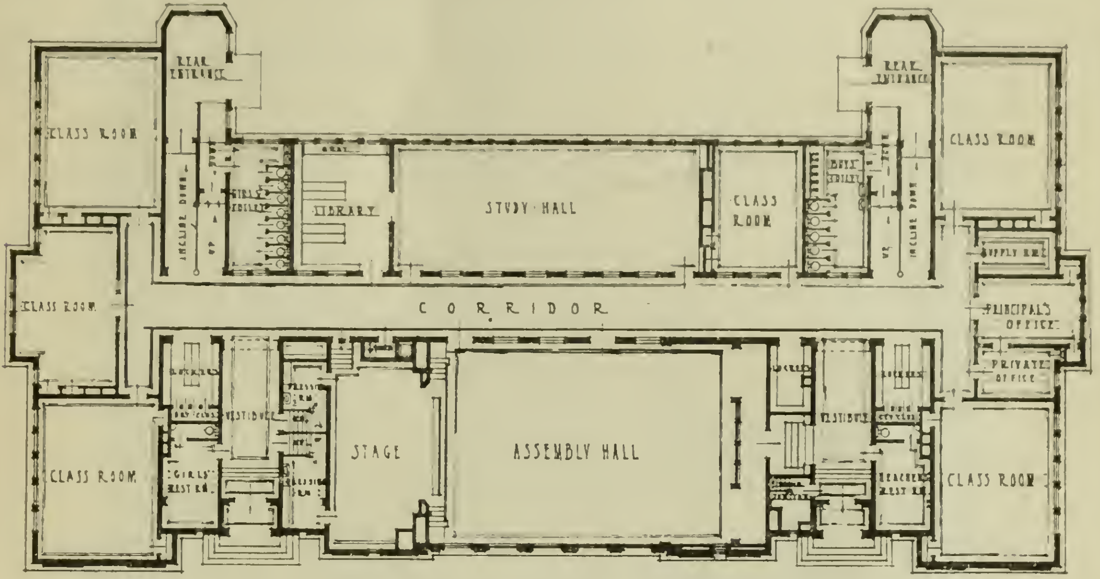


FIG. 2. FIRST FLOOR PLAN. WATSONVILLE HIGH SCHOOL.

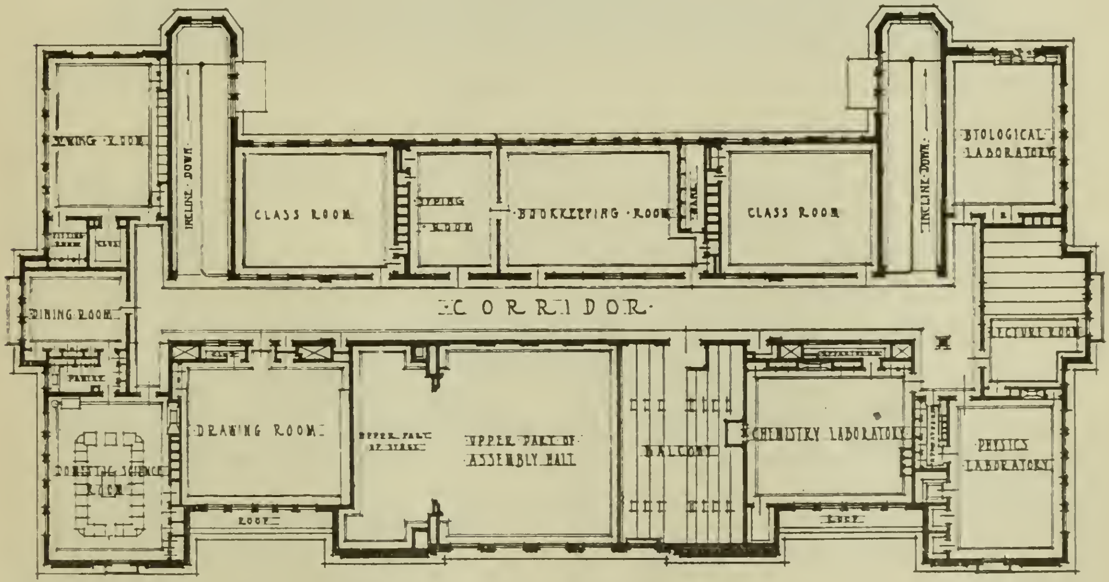
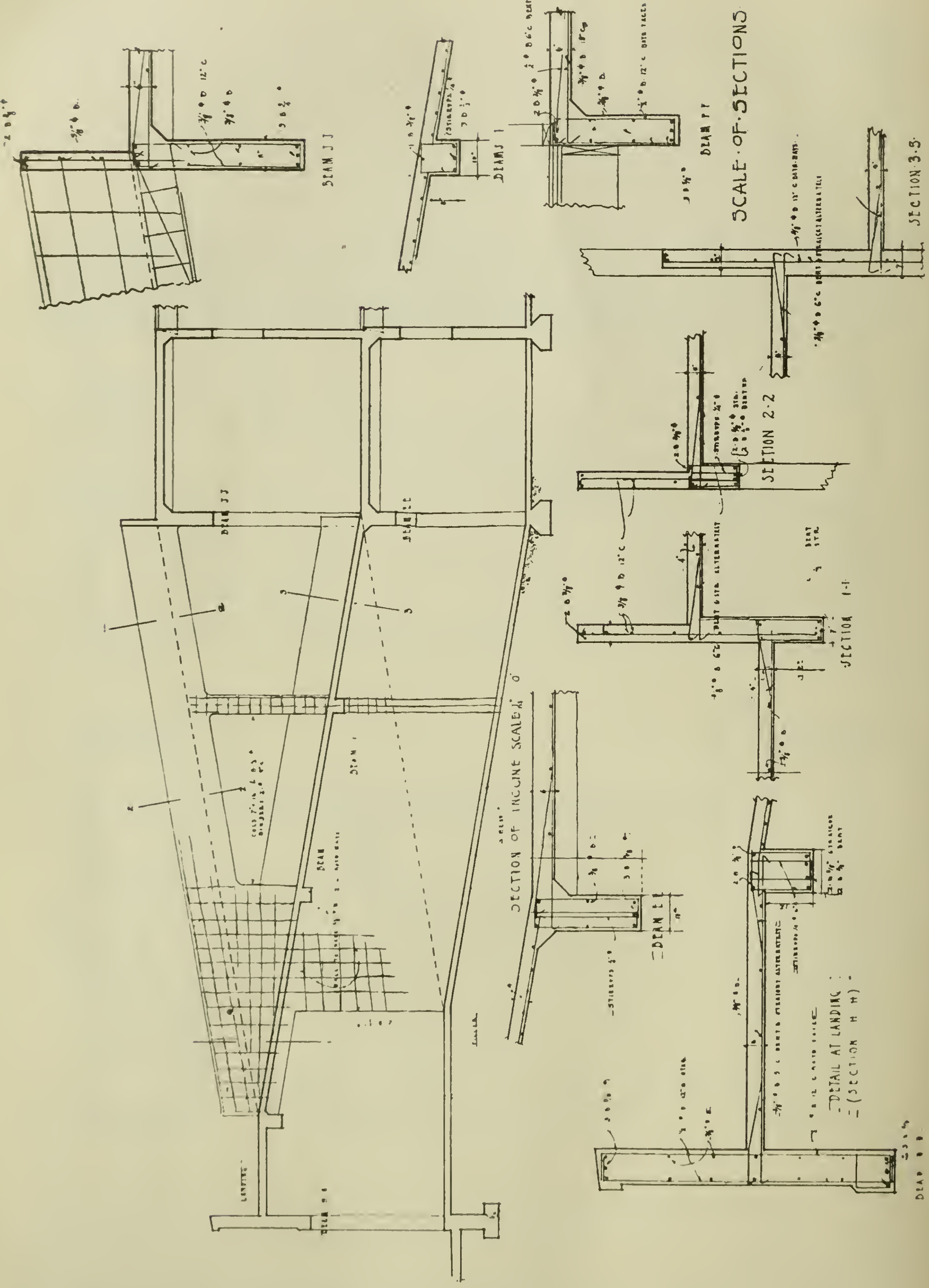


FIG. 3. SECOND FLOOR PLAN. WATSONVILLE HIGH SCHOOL.

The exterior of these buildings is coated with durable brick and cement coating, which gives the desired colour effect, besides making waterproof the outer surface.

In regard to the cost, the architect has found that better value is obtained in this type of construction than in the use of any other material



Sectional Details of Inclines at the Healdsburg and Watsonville High Schools.

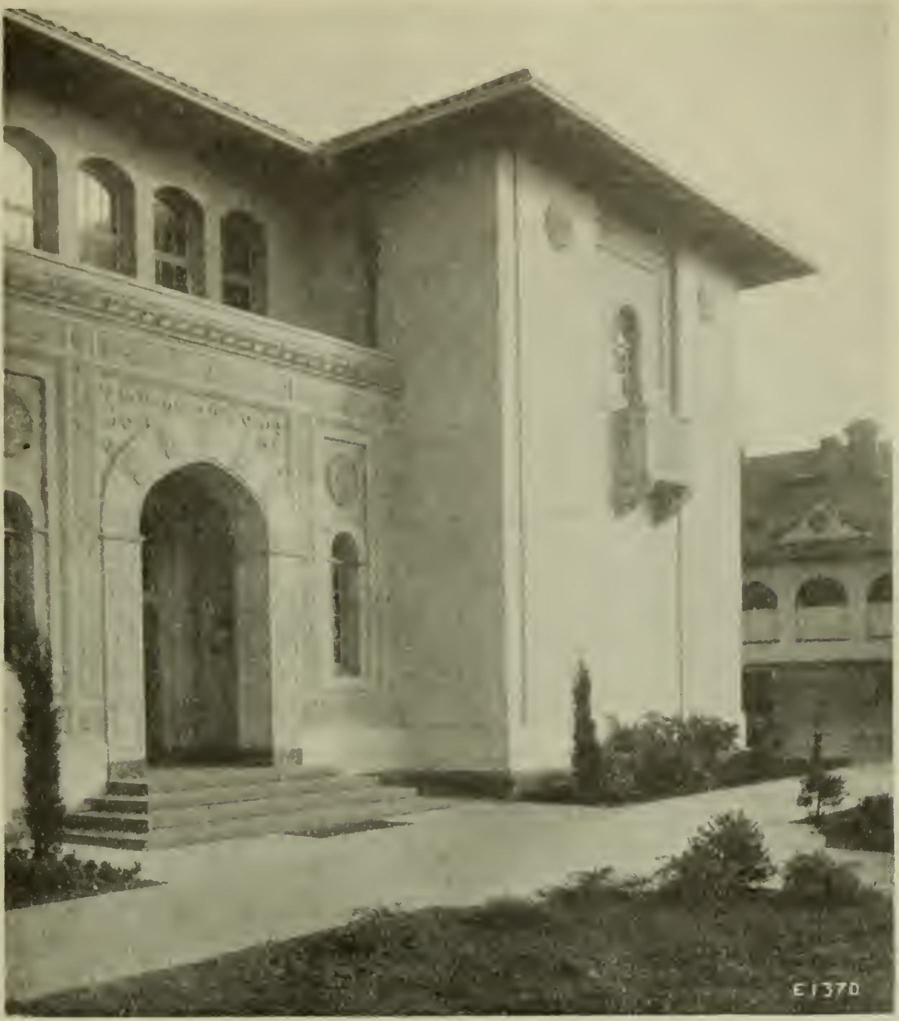


Fig. 4. Entrance Detail and End Pavilion, Watsonville High School.

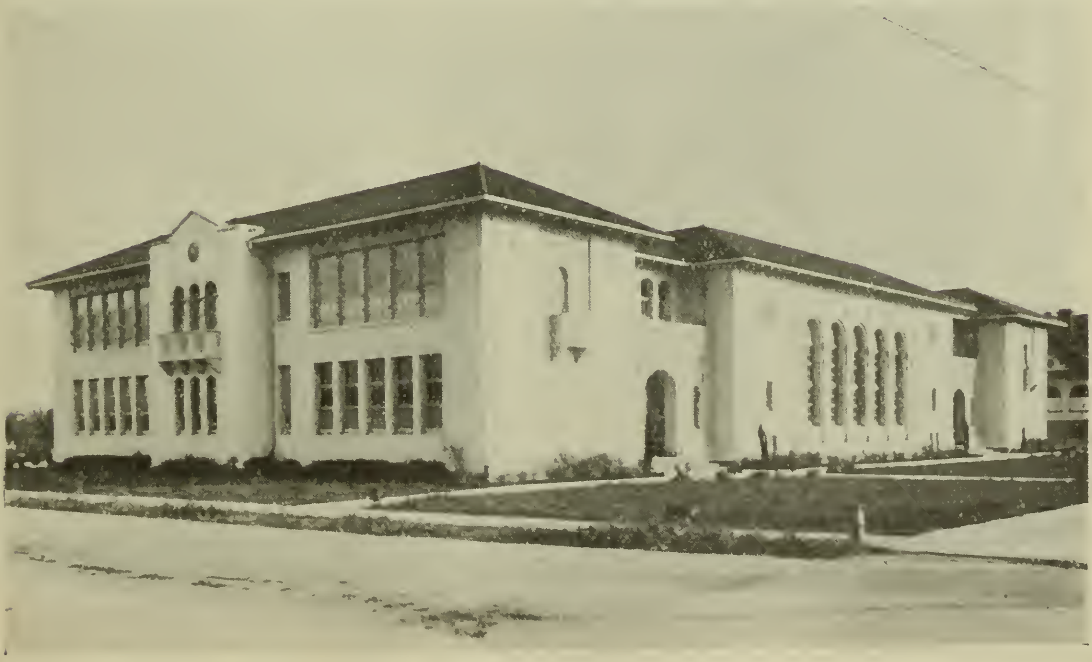


Fig. 5. High School, Watsonville.

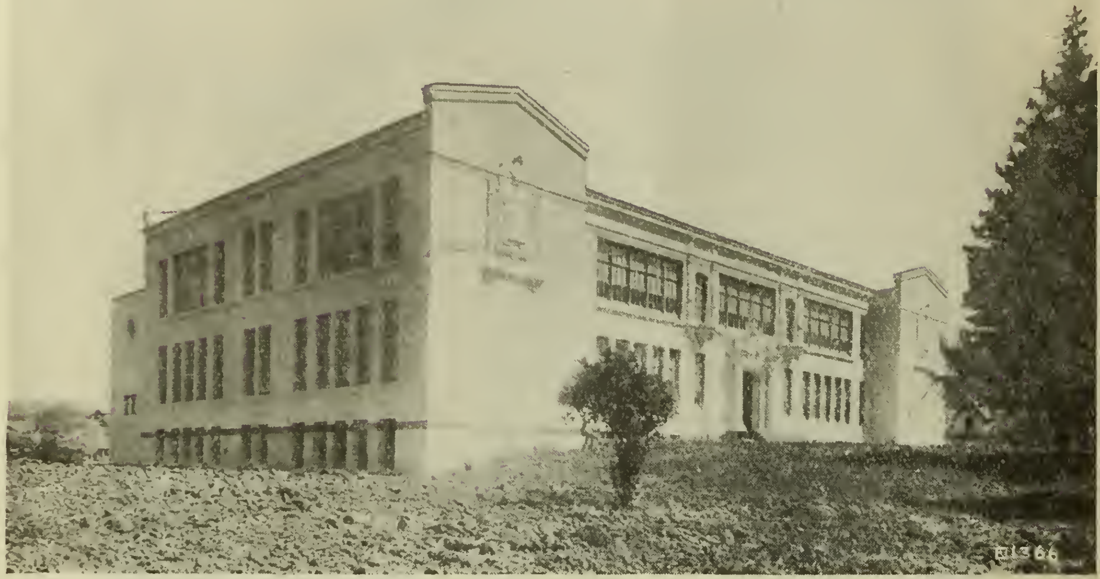


FIG. 6. HIGH SCHOOL, HEALDSBURG.

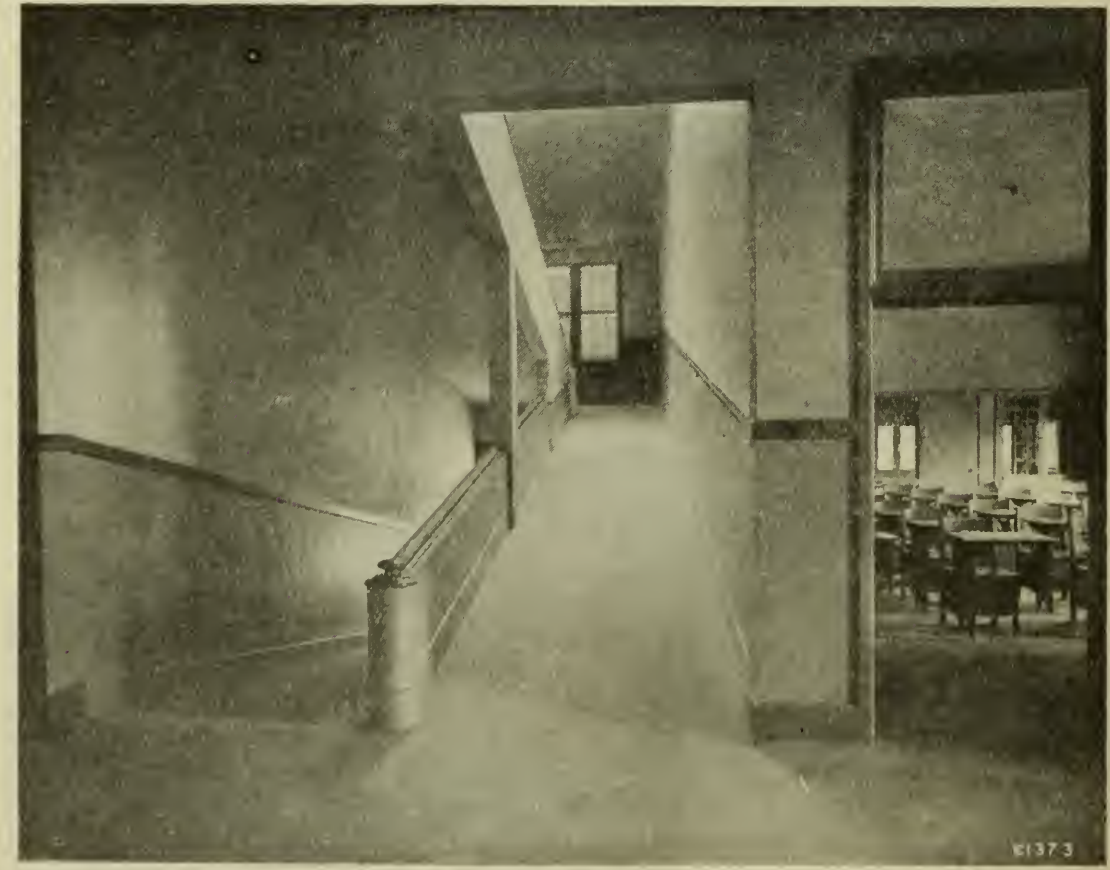


FIG. 7. CONCRETE INCLINE FROM FLOOR TO FLOOR, HIGH SCHOOL, HEALDSBURG.

except wood, and concrete lends itself splendidly to the styles of architecture best suited to the climate and environment of California.

A noticeable feature in the Assembly Room for the Santa Cruz High School (*Fig.* 9) is the absence of columns or rods. The balconies are carried on cantilever brackets of concrete.

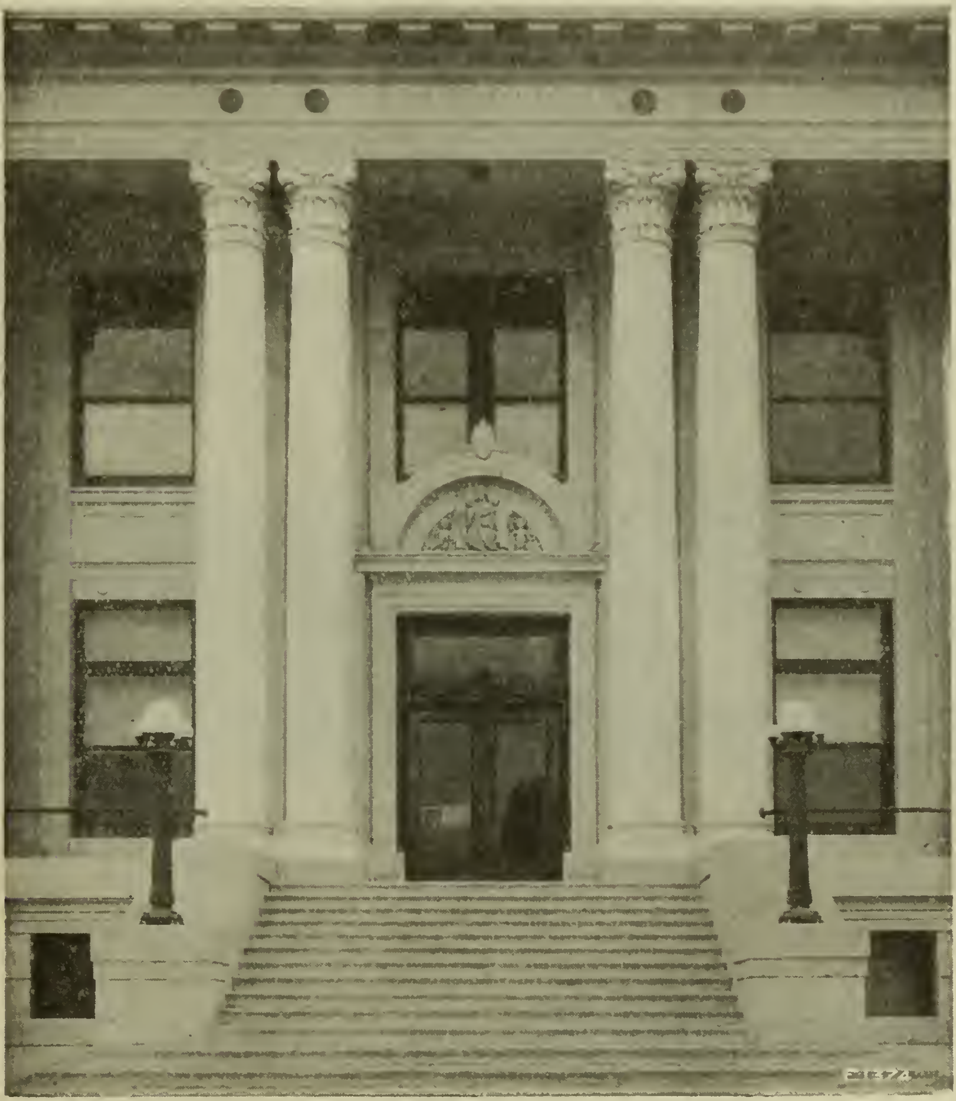


FIG. 8. ENTRANCE DETAIL, SANTA CRUZ HIGH SCHOOL.

The Santa Cruz High School is of similar construction to that of the Watsonville School. The walls are of monolithic reinforced concrete with a variation in thickness of 12 in. to 8 in., depending upon plan and necessary reveals and upon the loads to be placed upon them. The floors throughout are of concrete with wood surface, excepting that the corridors and some parts of the main floor and other places where fire-resisting construction was specially desired the floors are entirely of concrete.

The corridor floors are 7 in. thick with a span of 13 ft., resting on the corridor bearing walls. The stairways and rails are of concrete with steel balustrades ; steps have safety treads.

The outer walls are finished with a Portland cement plaster to represent a stone surface. The cost of the building was 13 cts. on the cu. ft. basis and $200.00 per pupil.

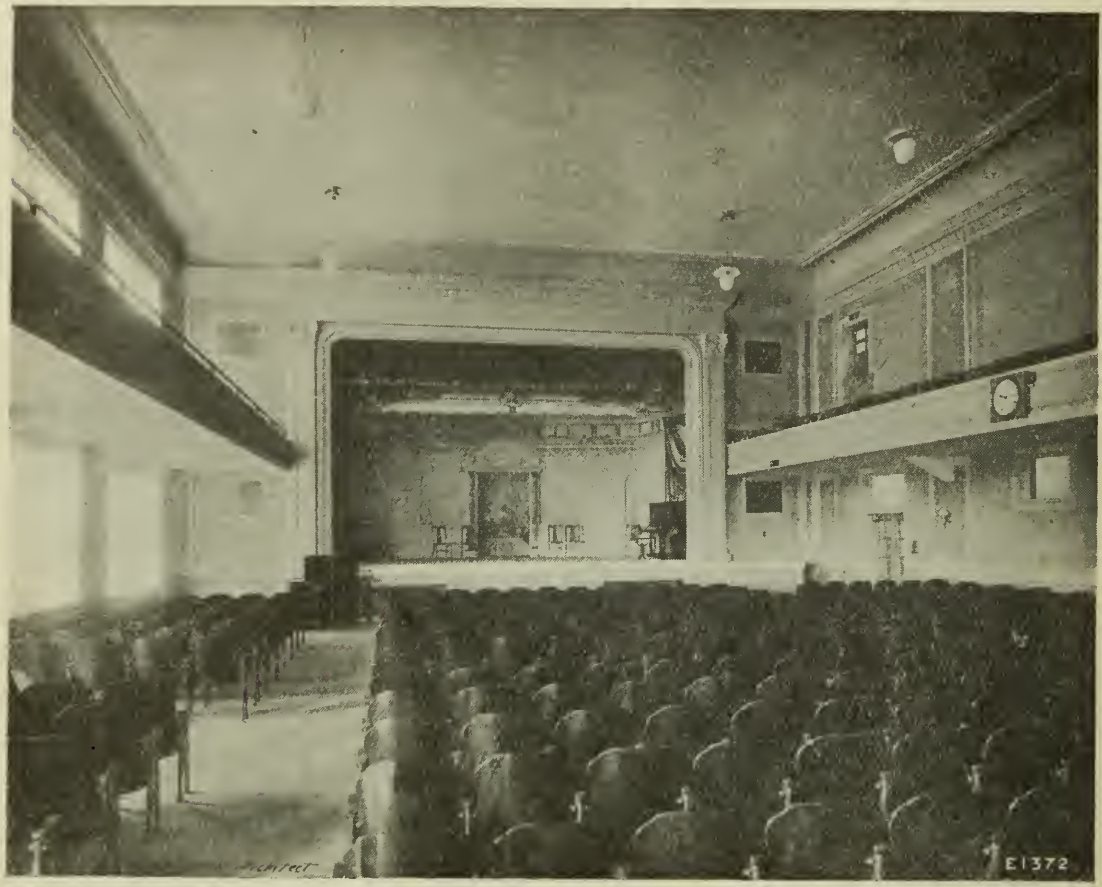


FIG. 9. ASSEMBLY HALL, SANTA CRUZ HIGH SCHOOL.
Showing Balconies suspended on cantilever concrete brackets.
(Notice freedom of rods and posts.)

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Mr. J. Harold Beaumont, Registered Patent Agent, of Messrs. Andrews and Beaumont, 204-6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of September, 1919.—ED.

Reinforcing Bars.—*Nos.* 132,219 *and* 132,039. *J. S. de Vesian and L. G. Mouchel and Partners, Ltd.*, 38, *Victoria Street, London, S.W.*1. *Dated September* 5/18.—The first of these inventions relates to reinforcing rods provided with continuous spiral or helical flutes along their length.

Fig 1

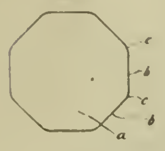
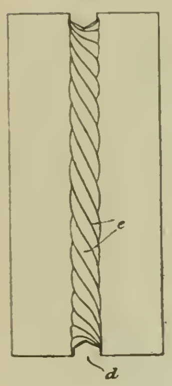


Fig 2



According to the invention, these flutes are formed in the process of rolling, without twisting the bar, the grooves (*d*) of the rolls being provided with helical projections (*e*).

The second invention comprises a treatment of reinforcing bars to eliminate the minute initial set in the material which is found to occur when the bar is first submitted to a tensile strain, even if such strain is smaller than that which would be required to reach the yield point of the material. The treatment adopted in accordance with the invention consists in subjecting the bars to an initial strain which is less than that required to reach the elastic limit.

In the case of a bar, for instance, which is designed to be stressed in a reinforced concrete structure to 16,000 or 17,000 lb. per sq. in., an initial pull of about 25 per cent. in excess, *i.e.*, 20,000 to 22,000 lb. per sq. in., is put upon the bars before embedding in the structure.

The same result may be obtained, in accordance with the invention, by subjecting the bars to a slight twist, which does not induce stresses reaching the tensile elastic limit of the metal.

The section of bar (*a*) adopted in this case consists of a number of straight or curved lines (*b*) meeting at obtuse angles, the edges (*c*) of which may be rounded.

Bars made by rolling in fluted rolls in accordance with the first invention may be subjected to the initial direct pull so as initially to stress the bar to about 25 per cent. in excess of the working stress.

Concrete Roads.—*No.* 131,453. *Major-General Sir G. K. Scott-Moncrieff*, 10, *Vicarage Gate, Kensington, London, W.* 8, *and J. Hines*, 289A, *Finchley Road, Highgate, London, N. Dated August* 22/18.—This invention consists in heating the road bed and treating it while hot with tar or other suitable waterproofing substance. A concrete foundation provided with expansion joints is then laid on the bed and is heated prior to the application of a coating of bituminous material.

The heating of the road bed (*a*) ensures an effective penetration by the waterproofing substance, which may be applied by the apparatus described in Specification No. 107,027.

The longitudinal expansion joints (*d*) and angular joints (*e*) are filled with material (*g*) which will prevent the entrance of moisture, but will possess the necessary degree of resilience to permit the expansion and contraction of the concrete or cement to take place; the preferred form of cement for the foundation (*C*) is the bituminous cement described in Specification No. 131,164.

Fig 1

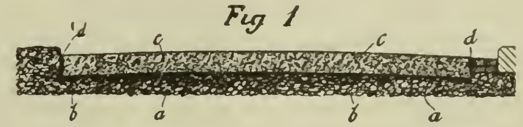
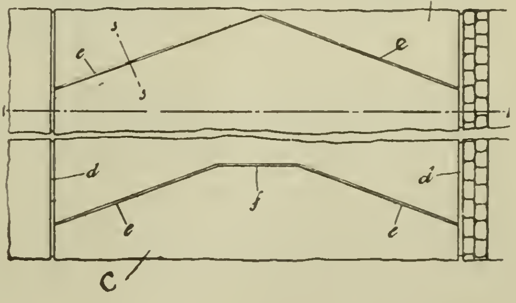


Fig 2



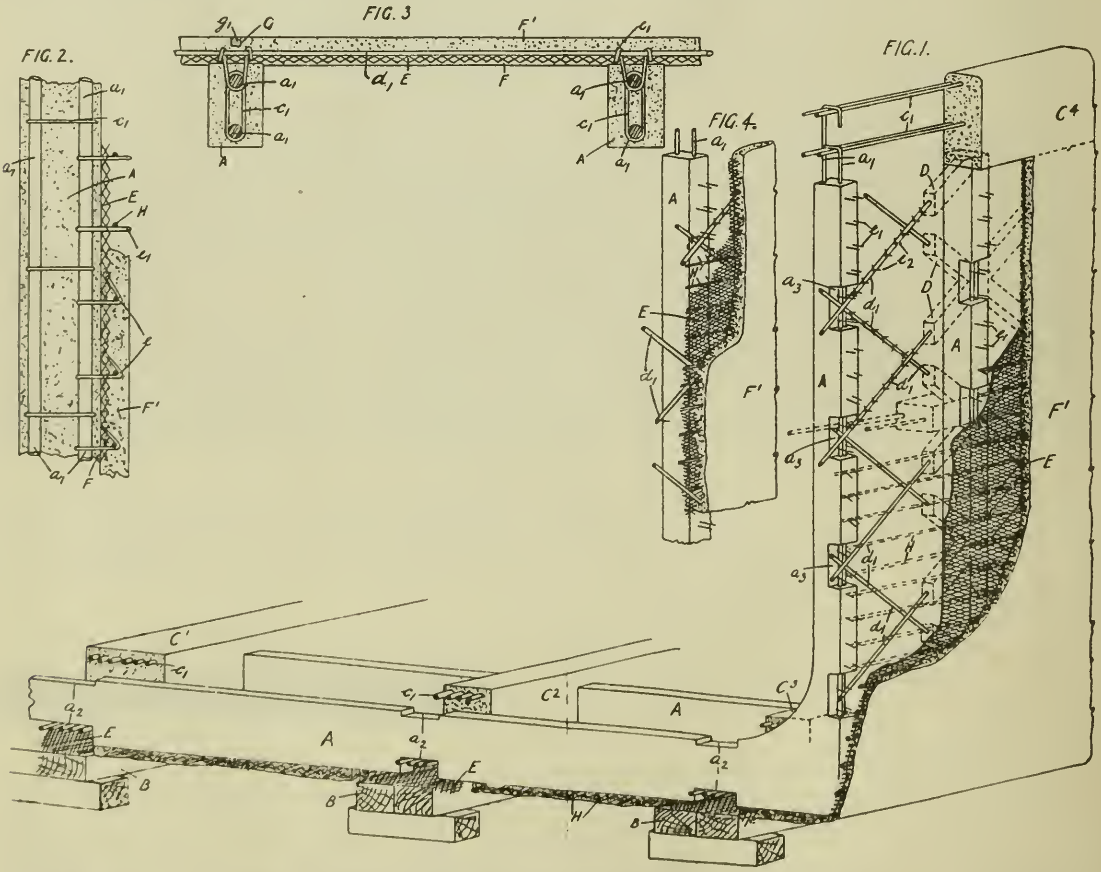
The transverse expansion joints are preferably from 2 to 2½ in. wide, arranged at intervals of about 40 yds. These may be formed by means of downwardly tapering wood strips 4 to 6 in. deep, protected at top and bottom with hoop-iron and provided at intervals with eye-bolts to facilitate removal.

Reinforced Concrete Ships, etc.—*No.* 131,945. *H. C. Ritchie,* 635, *Royal Liver Buildings, Liverpool, and M. Kahn, Caxton House, Westminster. Dated April* 24/18.—This invention comprises an improved method of constructing reinforced concrete ships which consists in first assembling in position the main frame members, diagonal bracing and webbing supporting bars ; then attaching to the contour by means of stirrups a metallic webbing of expanded metal, etc., so that it is attached to the frame members and stiffened between them by the bars ; and, finally, plastering the webbing on both sides with cement mortar, the diagonal bracing members being so arranged that they form an integral part of the main frame members and the shell.

The frame members (*A*) are assembled on timber supports (*B*), and are held in position at the requisite distances apart by temporary timber bracings.

The longitudinal members (C^1—C^4) are cast *in situ* in the case shown, gaps (a^2) being left in the transverse frames (*A*) for the passage of the reinforcing bars (c^1) ; similar gaps (a^3) are formed in the frame members to permit the passage of the reinforcement bars (d^1) of the secondary bracing members (*D*), which in this case are arranged diagonally. Stirrups (e^1) cast in the members (*A*) are secured to the bars (a^1), and similar stirrups (e^2) are attached to the diagonal bars (d^1).

FIG. 2. FIG. 3 FIG. 1. FIG. 4.



Light bars (*H*), arranged horizontally or diagonally, are secured to the frames (*A* by the stirrups (e^1), and the webbing (*F*) is supported between the frames by these bars (*H*), to which it is attached by wire ties, and is secured to the bars (d^1) by the stirrups (d^2), which are hooked over the mesh.

The shell of the ship is formed by plastering cement mortar on both sides of the webbing so that the inner and outer coatings (*F*, F^1) become united.

The bracing members are now completed by casting *in situ* the concrete parts (*D*), these parts thus becoming integral with the frames (*A*) and with the shell. Grooves (*G*) are formed at suitable intervals (about every six frames) to form expansion joints. These grooves are filled with bituminous material, which will cover up any crack occurring at the joints.

Reinforced Concrete Floors, etc.—*No.* 131,178. *C. M. J. Roch and L. G. Mouchel and Partners, Ltd.*, 38, *Victoria Street, Westminster. Dated August* 29/18.—The object of this invention is to combine the advantage of T-beam action in floors cast *in situ*, with the saving in formwork obtainable with pre-cast work.

In accordance with the invention, the beams are pre-cast with only the reinforcement which would be provided if cast *in situ*, and they are then placed in position and strengthened temporarily by ties and struts, whereupon the structure is completed.

The main beam (*g*), *Fig.* 1, is cast with gaps (*r*) to accommodate secondary beams, and with holes (*p*) to take bolts, by means of which the temporary ties (*d*) are held. The temporary struts (*c*) are tightened by wedges (*a*), and may be provided with counter-bracing (*n*). The ties may take the form of links and chains, as shown, or wire ropes or chains only.

Fig. 12.

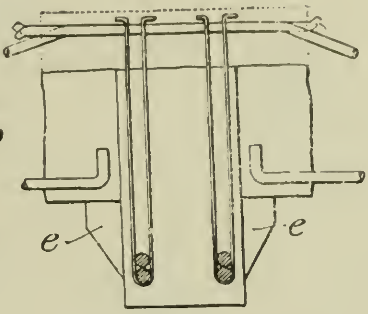
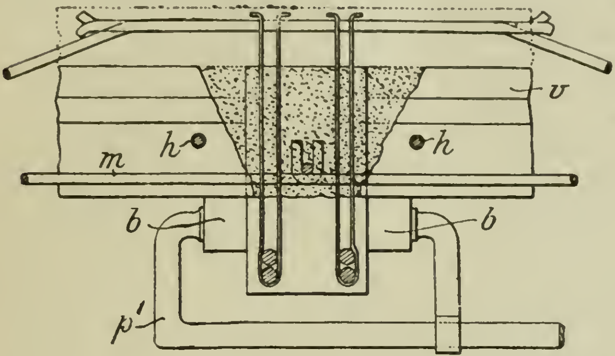


Fig. 7.



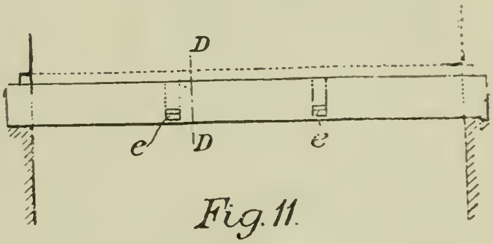


Fig. 11.

Fig. 8.

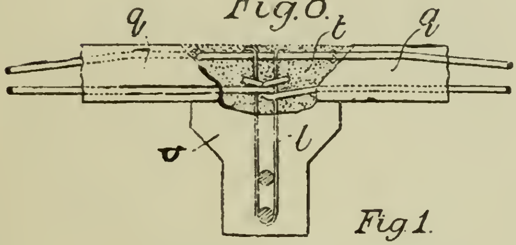


Fig. 1.

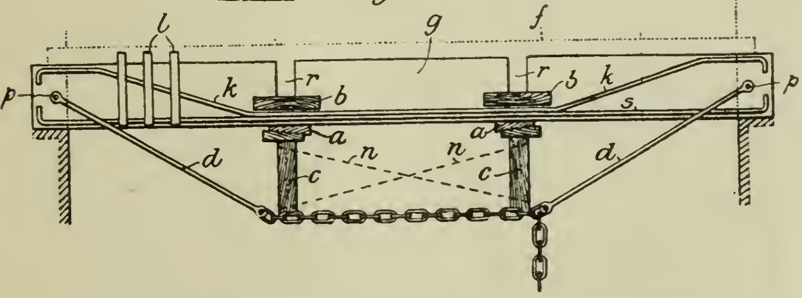
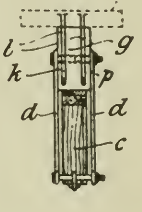


Fig. 5.



The ends of the secondary beams are cast with chamfered edges, and may rest upon temporary blocks (*b*), *Figs.* 1, 7, clamped against the sides of the main beams.

As an alternative, corbels (*e*), *Figs.* 11, 12, may be cast on the main beams, in which case the gaps (*r*) may be omitted.

Slabs (*q*) of concrete or reinforced concrete rest between the beam, their length being such as to leave a gap (*t*), *Fig.* 8, to be filled in later with concrete, and the ends of the slabs may be chamfered and provided with projecting reinforcement, which may be connected to those of an adjoining span, as shown. These slabs may be of the full floor thickness or they may be thin slabs which will act as centering for additional concrete to be laid over them.

In some cases, as, for example, in the case of light roof trusses, the strengthening means, consisting of ties and struts, may form permanent parts of the truss, to facilitate lifting and placing in position.

Concrete Silos.—*No.* 131,735. *Trent Concrete, Ltd., Chelsea Street, Nottingham, and E. F. Sargeant, Trent Navigation Buildings, Wilford Street, Nottingham. Dated August* 29/18.—According to this invention, the doors or shutters for the openings of concrete silos are arranged on the outside of the silo, and the floor is constructed without any support from the side walls or foundations, so that it can settle down irrespective of the latter should the ground on which it is laid sink under the compression due to weight of material.

Fig 1

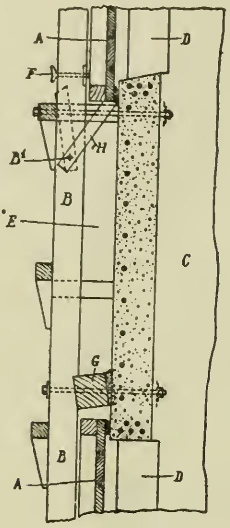
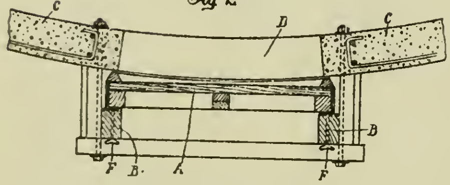


Fig 2



The doors or shutters (*A*) for closing the openings (*D*) are supported against the internal pressure by using the ladder strings (*B*), which are made of requisite strength, and are securely bolted to the wall (*C*) of the silo.

The doors can be raised and lowered in the space (*E*) between the ladder strings (*B*) and the walls (*C*), and are clamped in the raised position by clamping screws (*F*). Stops (*G*) may be provided between each opening (*D*) to act as stops for the doors in their lowered or open position, and these stops may be so constructed as to form weather boards for the door below and to prevent rain from getting between the door and the wall of the silo.

Pivoted catches (*H*) are provided to hold the doors in raised position prior to their being clamped by the screws (*F*).

The walls (*C*) of the silo are erected on foundations which are carried down until firm ground is reached, but the floor, which is reinforced, is merely laid upon the surface of the ground at floor level, so that settlement of the floor under the weight of the silo contents may take place irrespective of the walls and foundation.

Reinforcing Bars.—*No.* 131,851. *J. S. E. De Vesian*, 38, *Victoria Street, Westminster. Dated April* 8/18.—This invention relates to twisted mild steel bars used for reinforcing concrete structures, and consists in the use of a cross-section of the bar provided with flats or depressions in which there is a special relation between the radii of the circles circumscribing and inscribing the section.

This relation is defined as follows :—Let R be radius of the circumscribed circle C, and r the radius of the inscribed circle D, and let T tons per sq. in. be the ultimate stress of the material of the bar before twisting.

Then $R—r$ must be less than $\frac{\pi R}{T}$ in a bar made in accordance with the invention.

In the case of mild steel with an ultimate strength of 28 tons per sq. in., for instance, $R—r$ must be less than $0{\cdot}112 \times R$.

Figs. 1 to 3 show sections which do not fulfil the conditions of the invention, while *Figs.* 4 to 7 show sections which comply with the conditions specified.

Fig.1.

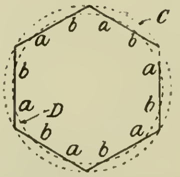


Fig.2

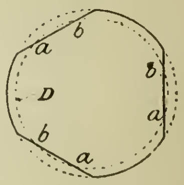


Fig.3

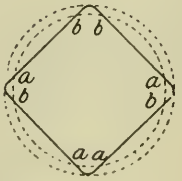


Fig.4

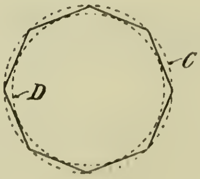


Fig.5

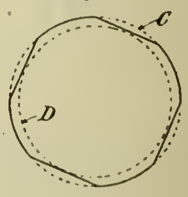


Fig.6

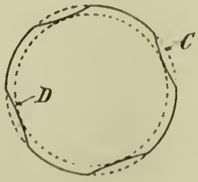
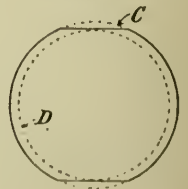


Fig.7



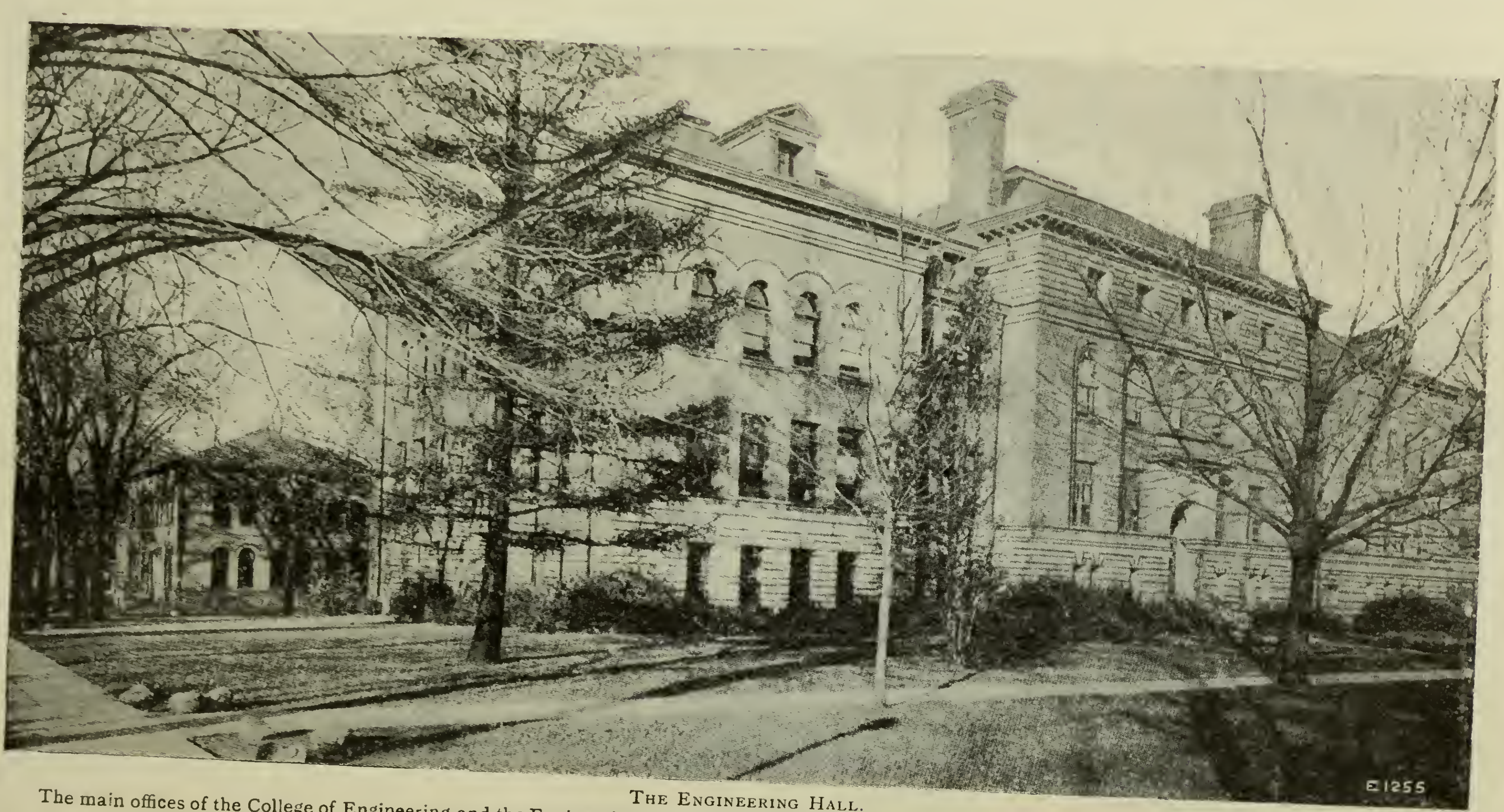
AN ENGINEERING COLLEGE IN THE UNITED STATES.

In order to mark the fiftieth anniversary of the founding of the Illinois University an illustrated pamphlet was published giving pictorial descriptions of the buildings, laboratories and other facilities for the instruction of engineering students and or engineering research afforded by the College of Engineering and the Engineering Experiment Station of the University. In the following pages we have reproduced a few of the illustrations which may possibly interest readers of this journal.

Fifty years ago few institutions in America offered instruction in engineering. Some progress had then been made in the education of civil engineers, and many of the colleges gave courses in surveying and drawing in addition to their regular work in mathematics, physics, chemistry and other subjects which are fundamental to the training of engineers. The organisation of the " Land Grant Colleges "—of which the University of Illinois is one—under the provisions of the Morrill Act of 1862, provided instruction in agriculture and the mechanic arts " in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." The establishment of these State institutions under federal aid marked the beginning of a really effective effort to train men for the practice of engineering.

From its beginning, the University of Illinois provided instruction in civil engineering, mechanical engineering, and architectural construction. Because of the increasing knowledge of pure and applied science and of the greater demands for men having highly specialised training, the work of the College of Engineering has been gradually extended and strengthened until now it includes twelve four-year curriculums, each of which leads to the degree of Bachelor of Science. These are in architecture, architectural engineering, ceramic engineering, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, general engineering physics, railway civil engineering, railway electrical engineering and railway mechanical engineering.

The curriculum in civil engineering affords specialised training in the construction and maintenance of highways, in irrigation, drainage and the reclamation of land, and gives general consideration to hydro-economics. It emphasises structural engineering, including the theory, design and construction of masonry, reinforced concrete and steel bridges, viaducts, buildings and other structures.



THE ENGINEERING HALL.

The main offices of the College of Engineering and the Engineering Experiment Station, the department offices of Architecture and Architectural Engineering, Civil Engineering, Municipal and Sanitary Engineering, the Engineering Library, and the Ricker Library are housed in this building.

The department embraces cement and highway laboratories which afford opportunities for the study of the various materials employed in the construction

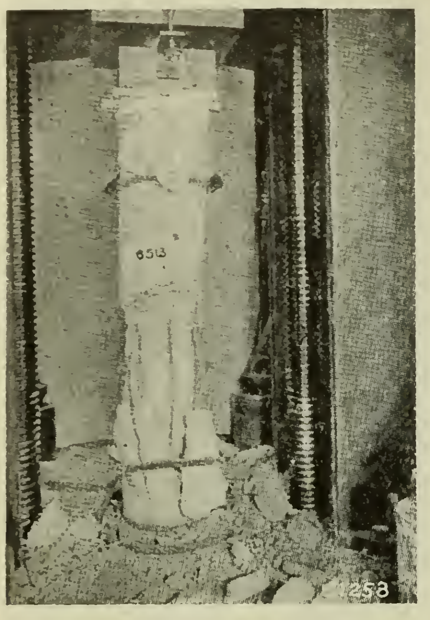
View in Cement Testing Laboratory. Students testing the various kinds of commercial cements.

of roads and pavements. It maintains a large equipment of surveying and other instruments essential to the profession.

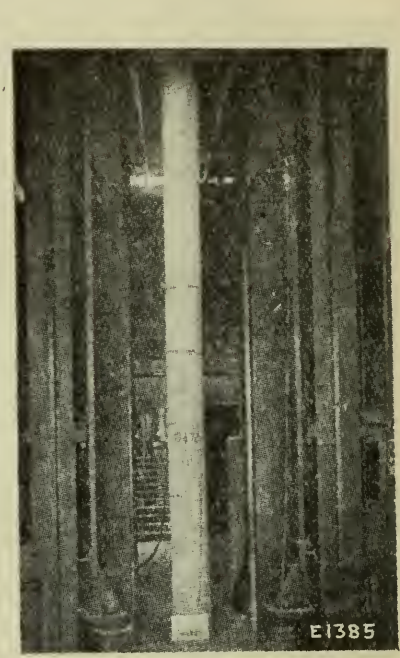
View in the Road Materials Testing Laboratory. Students examining the materials used in road building.
DEPARTMENT OF CIVIL ENGINEERING.

The Engineering Experiment Station of the University of Illinois is an organisation within the College of Engineering. It was created by an act of the

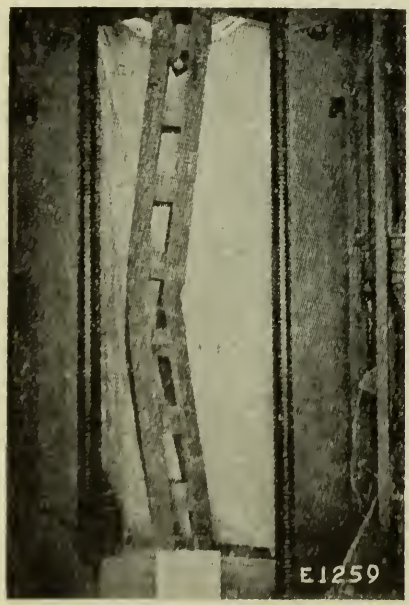
Board of Trustees on December 8th, 1903, to stimulate and to elevate engineering education and to investigate problems of special importance to professional engineers and to the manufacturing, railway, mining and other industrial interests of the State and of the country. The knowledge thus obtained is made available



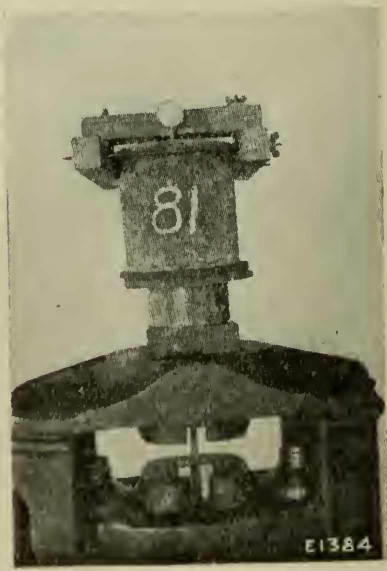
Reinforced Concrete Column.
View showing a concrete column with vertical steel rods after failure. The top of the column is covered with an iron plate embedded in plaster of Paris to ensure an even bearing. A load of 400,000 lbs. produced failure.



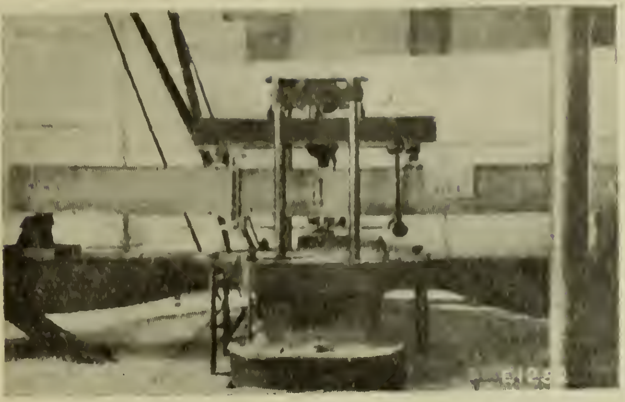
Test of a Concrete Column.
The column is 12 ins. in diameter and 20 ft long, reinforced with spiral steel wire hooping. Its top is not visible. The testing machine has a capacity of 600,000 lbs. and can be used for testing in either tension or compression.



Test of a Steel Column.
Failure of a built-up steel column made from angles and plates. This type of column is usually embedded in concrete to give stiffness and also for fire-resisting purposes.



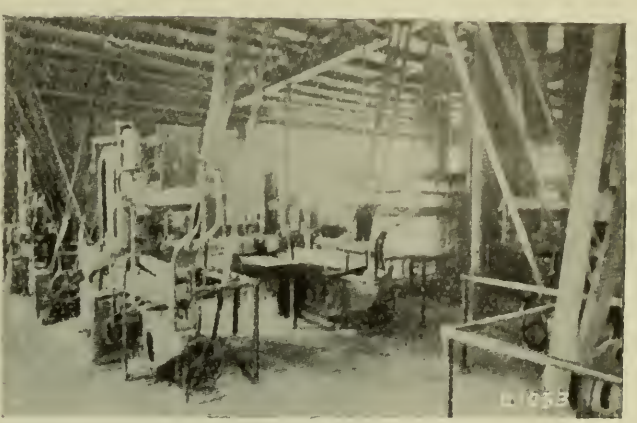
Test of Bond between Concrete and Steel.
The bond is determined by measuring the force and the slip as the steel rod is pulled out of the concrete.



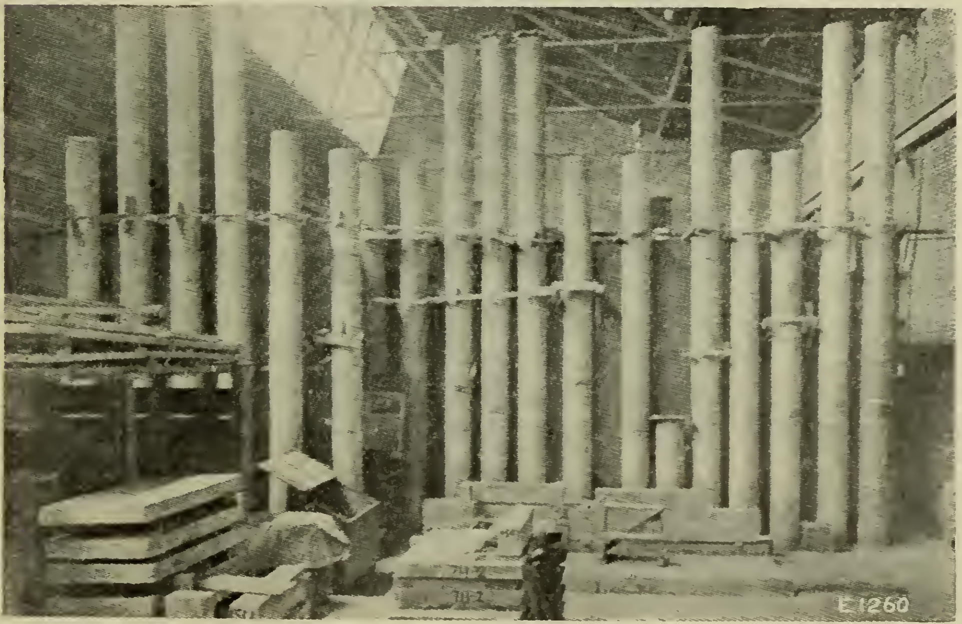
Test of a Reinforced Concrete Beam.

The beam is being tested in cross bending. Delicate micrometers are used to measure the stretch along the under side and the compression along the upper side.

View of one end of the laboratory showing several universal testing machines used for determining the strength in tension, compression or bending of building materials, such as iron, steel, timber, brick or concrete.



Materials Testing Laboratory.



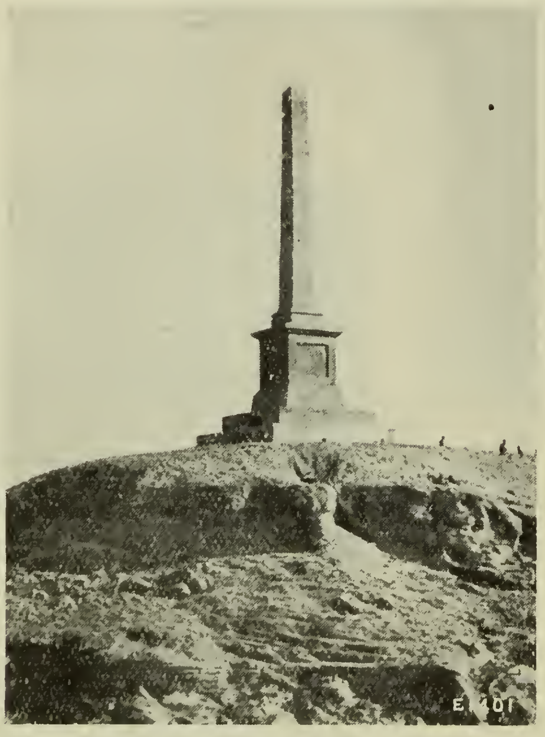
Concrete Test Specimens.

A view of the concrete laboratory where concrete specimens are made and cured. Concrete columns 12 ins. in dia. and up to 20 ft. long are shown in the rear and small beams and slabs in the foreground.

through the publication of bulletins presenting the results of original research, and of circulars containing compilations of important information not otherwise readily accessible to the interests to be served.

A REINFORCED CONCRETE MEMORIAL IN MESOPOTAMIA.

THE accompanying illustration shows a memorial erected in memory of the officers and men of the 13th Division who fell in Mesopotamia. The memorial has been erected on the right bank of the Dialah River, Mesopotamia, and has been built in reinforced concrete ; it stands 65 ft. high.



A REINFORCED CONCRETE MEMORIAL.

scription : To Lieut.-Gen. Sir Stanley Maude and his Comrades of all ranks of the Thirteenth Division.

The obelisk is reinforced at the corners with steel rails from the Baghdad Railway, tied round at intervals with Turkish telegraph wire.

The base consists of a grillage of steel rails embedded in concrete. Up the centre to within 3ft. from the top is a corrugated iron cylinder, 2 ft. in diameter, made up in sections and filled with shingle in order to economise the concrete. The concrete was mixed in the proportions of 5 : 2 : 1.

The material for the reinforcement was captured from the Turks.

The base is to have four bronze panels with the main inscription and the names of regiments and engagements. These are being made in England from captured trophies.

It is interesting to note that this memorial stands on the site where Cyrus, King of Persia, crossed the same river when he invaded Babylon.

We are indebted for our particulars and illustration to Lieut. G. E. Pearse, R.E., who was also the designer of this memorial.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.

THE ROADS AND TRANSPORT CONGRESS AND EXHIBITION, 1919.

REINFORCED CONCRETE ROADS: THEIR CONSTRUCTION, MAINTENANCE AND LIFE

Paper by **W. MATTHEWS JONES, M.Inst.C.E.,**
City Surveyor and Engineer, Chester.

In the following paper, read at the above Congress last month, Mr. Matthews Jones deals briefly with experiments made by himself at Chester, and refers also to other experiences in this country with concrete roads. We draw attention to the recommendations with which he closes his paper. Although the author deals with roads that have been described and illustrated in this journal from time to time, we have reproduced his paper with very little abbreviation, as it presents a useful summary of some of the experiments made in this country.

In attempting to write a paper in favour of reinforced concrete road construction, I know I am treading upon somewhat dangerous ground, and am likely to arouse a great deal of opposition amongst my fellow engineers and surveyors, because we in this country, speaking generally, know very little of such road construction and its possibilities. However, I hope that my paper will at least initiate a discussion which will throw new light upon the matter and that some good purpose will thereby be attained.

SOME EXPERIMENTS IN CHESTER.

Some nine or ten years ago a road widening in Chester had to be done, and it occurred to me that this would be an opportune time to try a concrete road surface. Accordingly, with the permission of my Highways Committee, an area of about 400 sup. yd. of concrete was laid. This was not reinforced, and was opened out a fortnight after completion. The surface has stood exceptionally well as a surface, but owing, in my opinion, to it having been opened for traffic too soon and to the lack of reinforcement, it became wavy and bumpy, although it did not actually break up. The whole area was laid 8 in. in thickness, and was on a clay subsoil. Two months after being opened for traffic I was afraid (owing to the waviness) of breaking up, and, therefore covered the surface with tarred chippings. This, in my opinion, obviated the breaking up, although the tarred chippings also became wavy, but not quite to the same extent as the concrete underneath. However, in the circumstances this first experiment stood well, and to-day the surface is not in a bad condition.

The second experiment was on a main road leading into the town and taking about 700 tons of traffic a day. The lengths laid in this case were reinforced; they were 5 ft. wide each, and about 50 yd. in length; each strip was placed between the tramway margin setts and the kerbs forming the footways. The reason for trying this system here was because neither water-bound macadam nor tar-macadam would stand, and these narrow strips had to be repaired continually. The reinforced concrete surface has stood exceptionally well, and has been down for about seven years. The concrete is tar-sprayed once a year. The tar-spray is afterwards covered before it is dry with ½ in. granite chippings.

In the third case, it was decided, seven years ago, that one of the streets in the centre of the town should be repaved with wood blocks as the old ones were worn out. The wood blocks were taken up and the concrete foundation exposed. This concrete seemed to be in perfect condition, and I therefore discussed with my assistant the question of concrete carriageways. His reply was that the concrete would crack and break up under any weight of traffic. However, bent on making an experiment, the 12-ton steam roller was sent down the next day, and two lines marked out along the centre of the concrete, and the roller was allowed to traverse up and down 200 times; this meant that 2,400 tons passed over that particular area of concrete without the slightest sign of a fracture being observed. Again my assistant was not satisfied, and suggested that the trial of a vehicle with broad rims like a steam roller was no proof of the effect of a vehicle with narrow steel rims, and, as a further experiment, the next day I sent my 1,000 gal. tar-spraying machine (loaded) down to the work. This machine, when loaded, weighs approximately 10 tons, and has to be drawn by the steam roller. It was sent up and down the same track as that used by the roller on the previous day, and again there was no sign of cracking or breaking up. The steel tyres of the tar-machine are 4½ in. wide. This experiment convinced me of the suitability of concrete as a carriageway surface.

About this time the Corporation had served notice on the frontagers under the Private Street Works Act, that a certain road in the district, known as Robert's Lane, should be repaired and put in order, the estimated cost of the work being £1,500. The owners and frontagers objected, however, to the work being done at this cost. I then determined to make a bold bid for reinforced concrete road carriageways, and submitted fresh estimates to my Committee showing that the work could be done for £960. This scheme was placed before the owners and frontagers and agreed to. The work was carried out for the estimated figure, and, although taking only about 100 to 120 tons of traffic per day, this road has given the most complete satisfaction, and is as good to-day as when it was laid. This carriageway actually cost 5s. 1d. per sup. yd., and the maintenance has during the past 6½ years cost the Corporation, on an average, 1½d. per sup. yd. per annum, this being for tar-spraying the surface and covering with chippings. After this, one or two small areas in side streets were tried with the same result.

White Friars was the next carriageway treated, and here again the work was successful, although for light traffic only. The cost of this work came to 6s. 3d. per sup. yd.

My Highways Committee have been so satisfied with these works that they are now allowing a reinforced concrete carriageway to be laid right through the main thoroughfare of the City, viz., Foregate Street and Eastgate Street. This street takes all the through traffic from Manchester, Warrington and Liverpool to North Wales, and, speaking roughly, there is not less than 1,500 tons of traffic passing over this roadway each day. Along the centre of these streets is a double line of tramway track, and this is being concreted in at the same time. A portion of the work has been completed and opened for traffic, and up to now the results have been all that was anticipated. Of course, three and a half months' wear is really little to go by, but very careful observations are being made of the work, and in the event of its proving a failure it will be possible, from the statistics obtained, to find the cause and so remedy it in the future. The sanction of the Local Government Board was received to do this work, and the Road Board have shown their interest in the experiment by granting the full estimated amount for carrying it out, viz., £5,000. This work was estimated for last January, at a cost of 11s. 3d. per sup. yd., but up to now the cost has been 12s. 9d. per sup. yd.; this is owing to the price of cement going up 8s. per ton, granite 1s. per ton, a slight increase in the cost of labour, and also to a strike of the men engaged on the work.

If this scheme proves a success I shall ask my Committee to allow immediately eight miles of roads, which at the present time require reconstructing, to be done in a similar manner. It may be interesting here to say that if the eight miles of roads are reconstructed with reinforced concrete, the estimated cost will be 13s. per sup. yd., making a total of £82,368. If the work were done with granite sett paving on concrete foundation I could not in Chester estimate a lower cost than 25s. per sup. yd., or a total of £158,400, or, again, if it were done with tar-macadam, including a foundation, 17s. per sup. yd., or a total cost of £107,712.

From these figures it will be seen that a reinforced concrete carriageway shows such a saving that if we can only construct these roads on right lines no other method will, in my opinion, stand a chance.

METHOD OF LAYING CONCRETE.

Perhaps it will be convenient to state here the method adopted for laying this concrete, and other facts, which are as follows :—

When considering the question of reconstructing the main street of this City a report was submitted as to two ways in which the street surface (which is at present paved with wood blocks in bad condition) could be reconstructed ; one for a reinforced concrete surface, the other for a granite sett paved surface. The former was estimated to cost £5,000, the latter, £11,000. These figures showed such a difference that the Council agreed that the Highways Committee should try the experiment of reinforced concrete for heavy traffic.

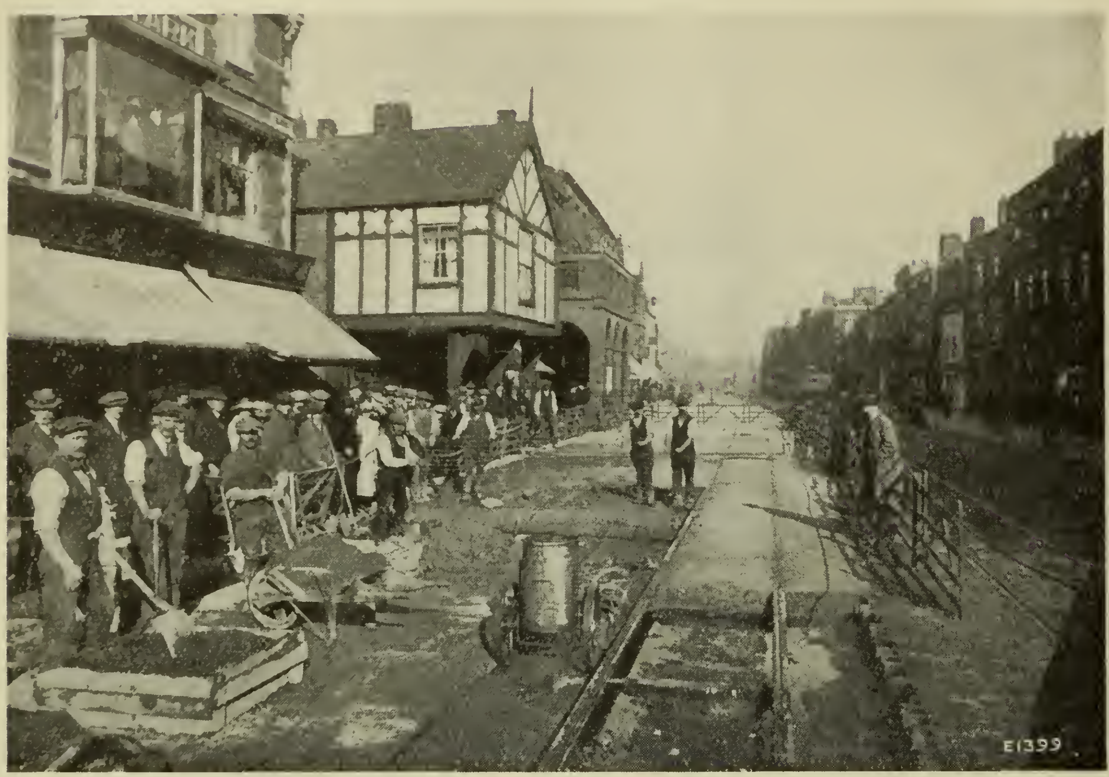
The concrete is mixed in the proportion of 5 to 1. The granite used is of the following sizes : 1½ in., 1 in., ¾ in., and ½ in. These are mixed in equal proportions, as I have come very firmly to the conclusion that it does not do to lay the larger material in the bottom and bring the finer material to the top. The secret in reinforced concrete road construction is to have all the interstices filled ; one must have no voids, and, by the mixing of the different sizes we get a perfect mass or conglomeration of the matrix, which is as necessary in a road as it is in a concrete floor or beam. The proportions of the concrete are 3½ of granite, 1½ of clean sharp sand to 1 of cement. The sand must be perfectly clean and free from clay or soil. The cement must be of the best quality to be obtained and of medium setting. The reinforcement used is that of a well-known engineering firm, and seems to me to be the best material for the work. I use what is known as their No. 9 Fabric. When the concrete surface has been completed—that is, after it has been trammelled to the contour and allowed to set, the surface is tar-sprayed and covered off with ½-in. granite chippings.

OTHER EXPERIENCES.

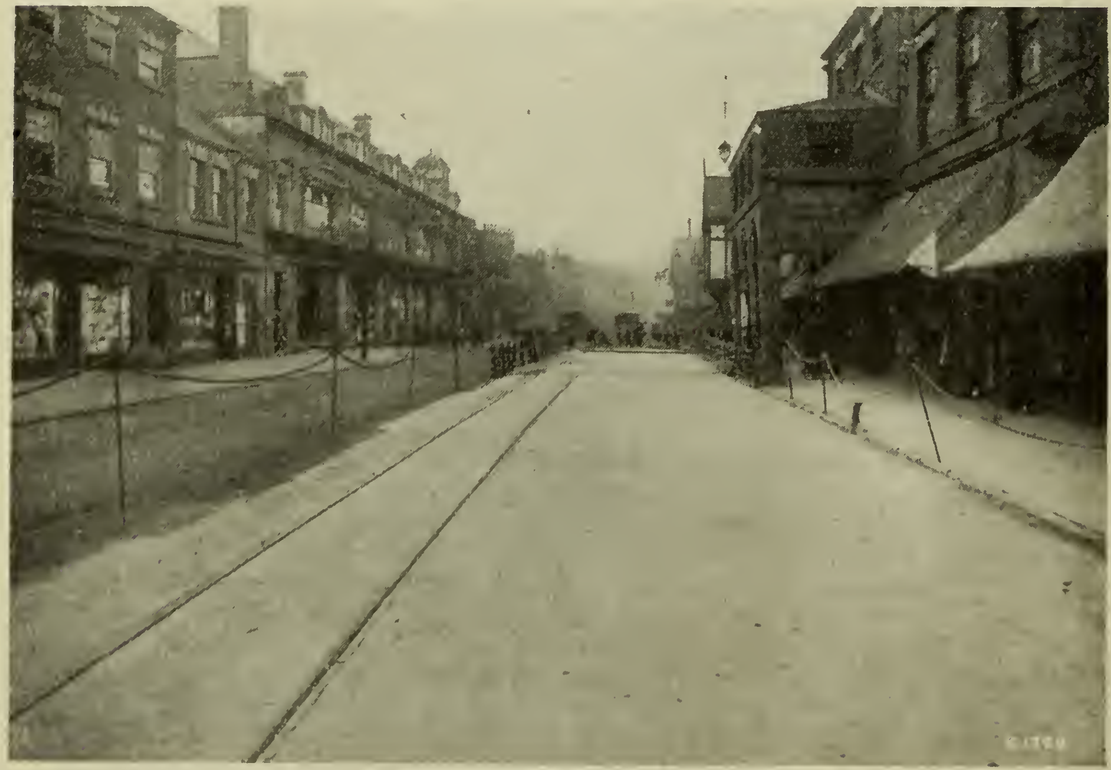
It will be remembered that between December, 1914, and March, 1915, Mr. H. T. Chapman laid an experimental length of reinforced concrete road near Gravesend, the subsoil of the district being chalk. The concrete was mixed in the proportions of 6 to 1, and the road takes at least 1,000 tons of traffic per day. For national reasons it was impossible to close the roadway to traffic, so it was decided to do half the width of carriageway at a time and allow the traffic to use the other half whilst the work was in progress. This method in a narrow carriageway is not to my liking, but the experiment has taught us many things which we did not know or understand.

However, the work was carried out under abnormally bad weather conditions. Frost prevailed on many days while, when there was no frost, more or less rain was coming down, and everyone who had made a study of this class of road construction therefore came to the conclusion that it would be a wonder if this road stood at all. Events proved that it did not stand, and that when the traffic ran over it the surface soon showed signs of wear and tear, and many holes appeared. The bad places were hacked out and tar-macadam laid on. In spite of this questionable failure, Mr. Chapman, however, decided to commence work on the other half of the carriageway and on this occasion he was favoured with better weather conditions. He also adopted a different method of construction, for instead of putting the full 6 in. in depth of concrete with a 6 to 1 mixture, he laid the bottom 4½ in. with 6 to 1, and the top 1½ in. with a richer and finer mixture, viz., 3 of grit and sand to 1 of cement. This second portion, which has now been opened for traffic since 1915, is as good as it was the day it was laid. This latter method of laying two-coat work is naturally more expensive and tedious than the mixing and laying of the concrete in one body. I am quite convinced, however, and I think Mr. Chapman will agree with me, that if the work of the first half of the roadway had been commenced, say, in March, 1915, instead of ending then, the whole roadwork would have been a great success.

Dealing with other reinforced concrete roads, the author then gave extracts from a paper recently read on " Roads " by Mr. R. L. Bendall, of Bournemouth, at a meeting of the Gosport Rotary Club in July of this year.



Road in course of construction.
B.R.C. Fabric is used for the reinforcement



A portion of completed road.
Reinforced Concrete Road, Foregate Street Chester.

With a view to showing the comparative strengths of reinforced and unreinforced foundations, I have been supplied by the British Reinforced Concrete Engineering Co. with the following figures for the " resistance movement " per foot width : Concrete 6 in. thick reinforced with No. 9 B.R.C. Fabric, 13,000 in. lb.; the same unreinforced only 4,000 in. lb. Concrete 9 in. thick reinforced with No. 9 B.R.C. Fabric, 23,000 in. lb.; the same unreinforced only 10,000 in. lb. Six inches of reinforced concrete is therefore equal to between 9 in. and 12 in. of concrete unreinforced.

In conclusion the author made a few observations as to the methods which should, in his opinion, be adopted by surveyors who are about to construct reinforced concrete roadways.

SOME RECOMMENDATIONS FOR LAYING CONCRETE ROADS.

1. Whenever it is intended to lay a reinforced concrete carriageway, the engineer or surveyor to the Council should give six months' public notice in the press of his intention, so as to give property owners on each side of such street an opportunity of having their gas, water, electricity or drainage services examined and, if found faulty, put right.

Further, whenever such services are examined, no charge should be made to such property owners for street repairs or maintenance from the time they have opened such roadway till such time as the surveyor commences his work. The upkeep and maintenance should be borne by the Council, as this does encourage examination and putting in order of the various services. Notice in writing should also be served on the water, gas and electrical engineers of the town.

2. If a new street is to be formed it should be arranged wherever possible that gas, water and electric mains should go down the footways, and wherever a pipe, line or electric main crosses the carriageway, they should be laid through stoneware pipes of sufficient diameter to allow (in case of bursts or escapes) of such pipe or cable being drawn from one footway to the other and so save breaking up the carriageways.

3. Drainage of the road bed is vital and should not be neglected and thought of no consequence.

4. The subsoil should be if uniform density and should be thoroughly consolidated.

5. The aggregate used must be clean, hard and tough, and free from foreign matter.

6. The fine aggregate (sand) should be coarse and well graded.

7. A rich mixture must be used.

8. Materials must be accurately proportioned, gauge boxes to suit the proportions should be accurately made, or if the mixings are done by weight then correct methods of weighing should be observed. Too much caution cannot be observed in carrying out this instruction.

9. Mixing must be thorough. If by hand, not less than twice dry and three times wet. If small areas are to be done it would not pay to mix by mechanical means.

10. Sloppy concrete must not be used. This is entirely a matter for the resident engineer or supervisor on the work to determine, as much depends on weather conditions prevailing at the time of laying.

11. Reinforcement is necessary, and not only strengthens the concrete but prevents to a very large degree cracking of the concrete.

12. Supervision must be intelligent and thorough and constant, for it certainly pays to have a conscientious assistant from the office or a reliable person in charge who will see that every mixing is properly gauged, turned over and laid. My practice is that not a mixing shall be done unless someone in authority and on my behalf is present.

13. Concrete must be prevented from drying rapidly. If this is not done it will be found that the upper surface, owing to either sun or wind, will dry more quickly than the lower portion. It is therefore advisable after the first twenty-four hours to water the surface of the concrete by means of a fine rose from a watering can as often as it may be thought necessary, the watchman on

the work doing this at night. I do not agree with covering the concrete over with wet sand and keeping the same damp.

Up to now I have found that, speaking generally, using a medium setting cement, it usually requires four weeks for the concrete to set before it is ready for traffic to go over the surface.

If the foregoing conditions are observed in the laying of reinforced concrete roadways we shall have few failures in this country in carrying out our work. Careful observations should be made as to weather conditions whilst the concrete is being laid, and a note taken of any other incidents that may appear to be trivial at the time but which may give us information as to the cause of any failure.

CONCLUSION.

In my opinion a reinforced concrete roadway properly made is to-day the most efficient and economical—it is waterproof, it is the most sanitary road that can be constructed, it is practically dustless in summer and mudless in winter, it reduces scavenging costs to a minimum and is practically non-slippery.

We are told by the Government that economy must be our watchword in carrying out our duties. English engineers and surveyors are sadly in want of first-hand information with regard to reinforced concrete roads. I would like therefore to take this opportunity of urging as strongly as I am able that the Ministry of Transport should appoint a few engineers and surveyors and some of the Ministry's officials to visit America and make a thorough investigation of reinforced concrete roads and the methods adopted by American engineers. A Report could then be brought up and circulated. Such deputation could make their investigations in, say, six weeks, and I believe the cost of such a visit and report would be infinitesimal as compared with the probable saving to the ratepayers of this country of some millions of pounds in the way of road construction and maintenance.

THE INSTITUTION OF CIVIL ENGINEERS.

ADMIRALTY HARBOUR, DOVER.

In the course of a paper read before the Institution of Civil Engineers on November 19th, Mr. Maurice F. Wilson, M.Inst.C.E., described the construction of the Admiralty Harbour at Dover. As the result of the findings of several Royal Committees appointed to consider the question of harbours on the south coast, Dover Bay was selected as the most eligible position, and the construction of the Admiralty Pier was commenced in 1847. This pier was practically completed for a length of 2,100 ft. in 1871. In 1897, Messrs. S. Pearson & Sons, Ltd., received a contract for the completion of the harbour, from the designs of Messrs. Coode, Son & Matthews, the work including the extension of the Admiralty Pier for a length of 2,000 ft., and the construction of an Eastern Arm 3,320 ft. in length, and a detached breakwater between the Eastern Arm and the Admiralty Pier, a distance of 4,212 ft. A sea-wall was constructed to the west of the Eastern Arm, and 21 acres of land were thereby reclaimed.

Generally speaking, the works were constructed of Portland cement concrete, all exposed faces from the level of 3 ft. below low water ordinary Spring tides upwards being protected by a facing of granite. The three main breakwaters were constructed with concrete blocks 6 ft. in height and 7 ft. 6 in. wide on the face, and in lengths so arranged as to give a thorough and efficient bond throughout the work. The sea and harbour faces were battered 1 in. to the foot, except the harbour face of the East Arm, which was built vertical, as it was intended for use as a quay. In the case of the heads of the different works, blocks of special shape were, of course, required. The foundations for the Admiralty Pier Extension and South Breakwater were laid upon a compact bed of flints and chalk marl. The outer end of the East Arm was founded on similar material, the shoreward end being founded on the bare chalk. As a general rule the foundations of the work were carried from 4 ft. to 5 ft. below the surface. Parapets were provided on the seaward side of both the Admiralty Pier Extension and the East Arm. In the case of the South Breakwater, which was not intended to be used as a quay, no parapet was provided, though provision is made for adding it if required. The cope level of all the works is placed at 10 ft. above high water ordinary Spring tides, the width at that level being 45 ft. in the case of the Admiralty Pier, 40 ft. for the South Breakwater, and 47 ft. 6 in. for the East Arm. The works were all finished off with a granite cope, backed by concrete pitching laid and grouted in cement. Boat steps, ladders and bollards were provided as required. The ballast for the concrete was obtained from Sandwich and Dungeness, the cement from the Thames district, and the granite from North Cornwall.

Two main workyards for the construction of the concrete blocks, etc., were provided. The concrete was mixed in Messent mixers of 1 cu. yd. capacity and then deposited in the moulds. In the east blockyard, the mixers were mounted on carriages which were travelled over the moulds upon an elevated railway, the concrete being dropped direct from the mixer into the mould. The whole of the machinery in this yard was worked electrically. The blocks, after being moulded, were left upon the floor for seven days before being lifted, after which they were removed and stacked ready for use. No block, however, was allowed in the work until it had been made for at least one month. When ready for setting, the blocks were run out from the yard on block trucks, and set in the work by means of goliath cranes travelling upon a staging spanning the work. The stagings consisted of clusters of piles placed in pairs, one on either side of the work, at 50 ft. intervals longitudinally. The piles were driven into the sea bed and securely braced. These pile clusters supported longitudinal girders, upon which were placed the service roads and roads carrying the goliath cranes.

The excavation of the sea bed was carried out by means of grabs worked from one of the goliath cranes upon the staging, this excavation being carried down to within 1 foot of the final depth, the last foot being excavated by hand and carefully levelled by men working within a diving bell, this also being manipulated from the staging by means of a goliath crane. The beds having been carefully prepared, the blocks were then set by diver, the blocks being set as closely as possible and without the use of mortar, and the work brought up to low water level. From low water upwards, the blocks were similarly set, but in a bed of cement mortar, the joints being grouted up solid and pointed. The best progress was made in connection with the South Breakwater, where 1,900 lineal ft. of foundation were constructed in one year, involving the setting of more than 13,000 blocks. In accomplishing this work, 1,300 lineal ft. of staging, one 20-ton derricking crane, one 60-ton goliath crane, and four 40-ton goliath cranes were in constant use. In November, 1907, a large liner entering the harbour struck the recently completed western head of the South Breakwater, removing bodily, for a distance of 4 ft., a length of about 80 ft. of work, the full width of the Breakwater, and 36 ft. in height. The total weight of concrete moved was about 10,000 tons.

FLAT SLAB OR GIRDERLESS FLOORS.

A Communication.

By WM. S. THOMSON, C.E., M.Am.Soc.C.E.

"THE London County Council would not consider this type of design under any condition." Such is the statement appearing in your issue of March, 1918, under the heading "Memoranda," and referring to a type of design commonly known as "flat slab" construction. This exceedingly unfavourable statement in reference to a system of construction that has passed far beyond the experimental stage, comes as a distinct shock to the engineer thoroughly familiar with the merits and advantages of the flat slab building.

If a question of public safety were involved, the London County Council would be fully warranted in taking such a stand, and their action would be endorsed by the engineering profession. But what are the real facts in the case? Beginning with 1903 there has been in the United States an annually increasing number of buildings erected in which girderless, or flat slab, floors and roofs have been employed. In the case of the company with which the writer is connected, they have increased their annual output of this type of design from an area of 500,000 sq. ft. in 1911 to 5,800,000 sq. ft. in 1916.

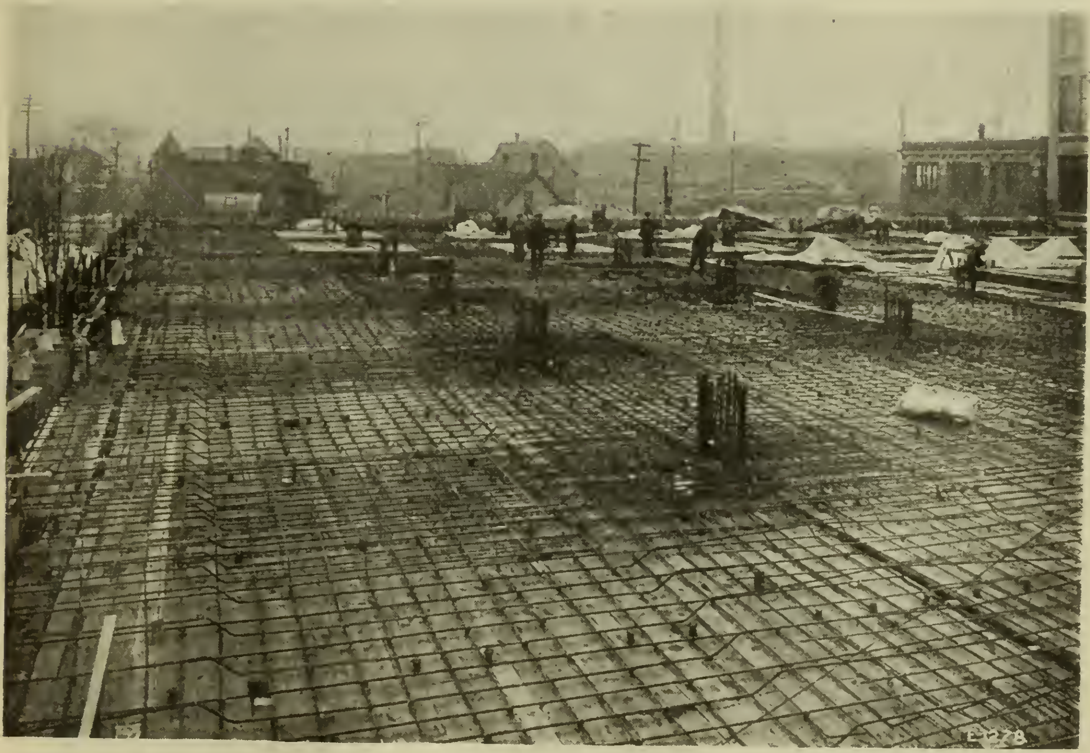
The areas given above are for the particular type of flat slab under exploitation by this company, and probably represent not more than one-third of the total of such construction. Such enormous expansion in this type of fire-resisting construction is an exceptionally strong argument in its favour, for failure either structurally or economically would very quickly result in its abandonment.

Why then should a community be denied the advantages to be gained through the employment of this construction? The question is especially pertinent in this time of world stress, when every possible economy must be practised and advantage taken of every legitimate means to overcome the rising tax on our resources and to meet the keen competition with which we are faced.

Some may say, granting that numerous flat slab buildings have been erected in the United States, what assurance is there that they possess an ample factor of safety? This argument may be answered in two ways—first, the majority of them have been in service a sufficient number of years under all manner of load conditions to thoroughly guarantee their integrity; and, second, numerous tests have been carried out to satisfy the correctness of the assumptions made in design. These tests have not stopped at measurements of deflection and recovery, but by means of the extensometer, or strain gauge, accurate determinations have been made of deformations in steel and concrete, thereby enabling one to compute the magnitude of the existing stresses under various loads, and their distribution throughout the slab. A record of several such tests is given in detail in *Bulletin*, No. 84, of the University of Illinois Experiment Station, Urbana, Ill., U.S.A., and further accounts have appeared and continue to appear from time to time in the technical journals and publications of engineering societies.

In the United States the girderless floor is universally accepted by city authorities, and is a construction that has come to stay. The Government has adopted it outright

An Automobile Assembling Room at Detroit, Michigan, completed.



Construction View of Automobile Assembling Building, Detroit, Mich.

Floor and roof area	280,000 sq. ft.
Panels	21 ft. 4½ in. by 22 ft.
Slab	8 in. thick.
Live load	125 lb. per. sq. ft.

INTERIOR VIEW—SPRAGUE ELECTRIC COMPANY'S BUILDING, BLOOMFIELD, N.J.

Floor and roof area	330,000 sq. ft.
Panels	25 ft. by 25 ft.
Slabs	200 lb. and 250 lb.
Live loads	200 lb. and 250 lb. per sq. ft.

AN AUTOMOBILE SALES ROOM AT ATLANTA, GA.

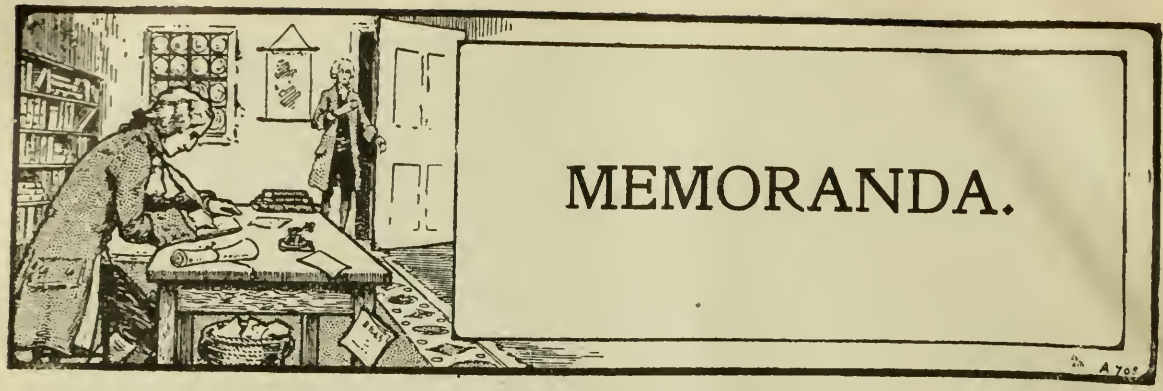
Floor and roof area	27,000 sq. ft.
Panels	19 ft. 6 in. by 24 ft
Slabs	8 in. by 8½ in. thick.
Live loads	120 lb. and 150 lb. per sq. ft.

for all of their fireproof warehouses, aggregating at this time more than 20,000,000 sq. ft. of floor and roof area and with many more buildings of the same type planned for erection in the immediate future. It carries a strong appeal to owner, architect, engineer and contractor alike on the score of utility and superiority as a fire resistant, adaptability, structural efficiency and economy. If this is true in America, why not in Great Britain ?

From the standpoint of our American experience it would seem that the action of the London County Council in summarily dismissing this type of construction is without justification, and in taking such a stand the community is deprived of the benefits accruing through the employment of a thoroughly efficient and economic structure.

The accompanying illustrations of buildings in the United States typify the thorough adaptability of the girderless floor to industrial and warehouse structures and convey better than words its possibilities, were it accepted by the cities of Great Britain on a basis similar to that adopted by municipalities in this country.

Exterior View—Automobile Assembling Building, Detroit, Mich.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Largest Concrete Blocks.—In his Presidential Address, read before the Institution of Civil Engineers on November 4th, Sir John Purser-Griffith referred to the complete success which had followed the use of what are claimed to be the largest concrete blocks ever used. These blocks, which each contained more than 5,000 cu. ft. of masonry and weighed about 350 tons, were used in the construction of the North Quay extension of the Port of Dublin. The blocks were built above high-water level and when sufficiently set were lifted by a floating shears or crane and deposited on a bed prepared by steam dredging ; they were levelled by men working in a large diving bell, entered through a tube fitted with an air lock. The same floating plant was used for laying similar large blocks for breakwater protection, and for the foundation of one of the lighthouses at the entrance of the harbour. These great blocks were designed by the late Dr. Bindon Blood Storey, F.R.S., M.Inst.C.E., the engineer of the Dublin Port and Docks Board, and for the work for which they were specially designed they proved a complete success, both from a structural and economic point of view By their use it was possible to build the extension quays without costly coffer-dams or heavy pumping.

Rebuilding in France.—The greatest interest is being shown in France to find the most suitable materials, etc., to rebuild the war-devastated areas, and the City of Lyons is now arranging for a further exhibition and Congress to take place in March of next year. At this exhibition it is intended to show machinery, materials, and various systems of building construction.

New Motor Roads in France.—The excellence of most of the French main roads has long been recognised ; but the war inflicted on them immense damage, directly and indirectly, by destruction in some parts, and by excessive wear, with reduced opportunities for maintenance, in others. In making good their roads the French are looking carefully to the character of the traffic which will pass over them, and are developing particularly concrete construction. A feature of the new roads will be the massive concrete abutment on each side where heavy traffic is expected. The roadway itself in these cases will have a minimum thickness of 4.7 in. of concrete, the camber being 1 in 100. Another type of road has a foundation of inferior concrete 4¾ in. thick, with a finished surface of superior concrete practically 2 in. thick. These roads have a decline of 1 in 100 from one side to the other, and thus no camber. Where the substratum is poor the concrete is reinforced with wire trellis-work. Before the war France had 100,000 motor vehicles ; the number now exceeds 200,000.—*Ironmonger.*

The Reinforced Concrete Chimney, 570 ft. high and 26 ft. 3 in. inside diameter at the top, built at Saganoseki, Japan, was the subject of some investigations by Professor Omori as to the movement of the top when subject to wind pressure. Wind velocities were recorded ranging from less than 1 mile per hour to a hurricane velocity of 78 miles. The amplitude of vibration at a velocity of 50 miles per hour was less than 1 in., while at 78 miles per hour it was 7.32 in. The maximum amplitude was in a direction at right angles to that of the wind. Professor Omori thinks that with the wind gusts of 110 miles an hour which they occasionally have in Japan the amplitude would be at least 15 in. The period of vibration was nearly constant for all velocities, varying from 2.52 to 2.56 secs.

The Technical Inspection Association.—An interesting paper was read at the Society of Arts on Friday evening, November 7, before the above Association by Professor Baly, C.B.E., F.R.S. (of the University of Liverpool), on the subject of "The Spectroscope in the Science of To-day."

Professor Baly dwelt upon the extreme importance of the spectroscope in all research work, giving instances of its extended use by three independent groups of scientific men, namely, astronomers, chemists and physicists, but the line of demarcation between these respective groups was so defined that very little information as to the work done by any one group was known to either of the others. Professor Baly urged the importance of the extended use of the spectroscope in all branches of scientific investigation, and he believed the time was approaching when it would be in daily use by the commercial exponents of applied science as much as by those working in the realms of pure science.

NEW CONCRETE BUILDINGS APPROVED OR IN COURSE OF CONSTRUCTION.

Reinforced Concrete Purifiers at Bromley.—Considerable extensions are being carried out in connection with the Bromley works of the Gas Light and Coke Company, and one of the interesting features is the overhead reinforced concrete purifiers, which are of an exceptionally interesting character. These purifiers evoked keen interest among a party of members from the London and Southern District Junior Gas Association, who visited the works last month and had an opportunity of seeing concrete building in all its stages from the foundations to practically the finished work.

Luton.—A large reinforced concrete warehouse is in course of construction at Luton on the Mouchel-Hennebique system. This will be the first building of the kind in the centre of the town, and it is designed to include a ground floor warehouse, a basement, a showroom on the first floor, and factory accommodation on the second floor. The building will have a floor space of about 18,000 superficial feet.

New Concrete Factory in Canada.—Official sanction has been received for the erection of a ten-story factory in Toronto for the Northern Aluminium Company. The building, which will be of reinforced concrete construction, will cost about $358,000. Messrs. Archibald & Holmes are the contractors for the work.

Reinforced Concrete Cinema.—A new cinema to be erected at Nottingham is to be built of reinforced concrete. The contractors are Messrs. Norris & Co.

A Hotel to be erected of Concrete.—We are informed that a hotel is being erected at Tramore in Ireland by Mr. H. A. Hamilton, of Waterford. The method employed being the same as was used for the concrete block dwelling illustrated in our November issue, p. 688.

Concrete Coal Bunkers.—The Islington Borough Council has accepted the tender of Messrs. Wilson, Lowatt & Sons, of Wolverhampton, for the construction of reinforced concrete coal bunkers, for £22,826.

CORRESPONDENCE.

Fibro-Concrete Blocks.

To the Editor of CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—I wish to bring to your notice that I have recently brought out and protected a concrete fibre-reinforced building block and slab, which, after giving it the usual tests, can be manufactured on the site at approximately one-third the present cost of any similar kind of composition.

For example: a block measuring 1 ft. 6 in. by 1 ft. 2 in. by 6 in. required, at 3 to 1 proportion, 16 lb. cement, 48 lb. of screened garden gravel, and 4 lb. 12 oz. of compressed fibre, total weight being 68 lb. 12 oz.

I believe this process is entirely a new one, therefore you may be interested in the method of manufacture, which is very simple, and can be easily undertaken by unskilled hands. The procedure being, first, to fill the bottom of the mould selected with the required thickness of concrete, say, for instance, 1 in. or $1\frac{1}{4}$ in. thick for the outside face; then lay in the compressed fibre on the top of this, allowing for an even

ALLOW us to introduce you to Harris—"'Arris the Oracle"—as his pals dub him.

He's just a working man, as you can see, not much good on mathematical calculations but from the practical point of view, what he doesn't know about driving piles isn't much.

As boy and man he's been on pile driving jobs most of his life, in almost every part of the world. He's been a pal to us in many difficulties, and if you watch this space in future he may prove a pal to you.

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thickness of, say, ¾ in. or 1 in. for the sides and ends; and, finally, covering the top with, say, ¾ in. or 1 in. thick, which would be sufficient for the inside face, the whole afterwards being well pressed or rammed down.

Needless to say, the moulds can be made in any shape, size, or thickness to suit the building to be erected.

As regards the method adopted for manufacturing the fibre for reinforcing the blocks and slabs, perhaps I ought to mention that I have invented and protected an adjustable press for this purpose from which I can produce finished smooth faced slabs of varying thicknesses and widths, which become so hard under pressure that it is very difficult to even penetrate the face or flat side with a sharp instrument, and will stand any amount of rough usage.

This press was intended in the first instance for agricultural use only, for the purpose of providing farmers with a quick and efficient straw, reed, or the like slab for covering in their stacks, barns, shelters, etc., and laid on in a similar way to slate or tile covering either pegged or sewn down, also for covering in village thatched cottage roofs and the like, where unskilled labour could be satisfactorily employed.

You will doubtless note, therefore, the utility of this press for both purposes, without mentioning its merits as a baling machine in addition.

I might add that I am prepared to give every facility to enquirers.

Yours faithfully,
B. Maddock,
Architect and Clerk of the Works.

Estate Office,
Elton Hall, Peterborough.

OBITUARY.

Mr. Thomas Potter.

We regret to have to record the death of Mr. Thomas Potter, at his residence in Croydon, on October 28th, a well-known writer on concrete and a constructional engineer and concrete specialist. Born in Kent nearly eighty-six years ago, the deceased was employed for some time by Mr. Brassey, the well-known contractor. He was subsequently in business as a builder, and then became Clerk of Works to Lord Ashburton in Hampshire, under whom he remained over twenty years. He then removed to Victoria Street, Westminster, and carried out many important works. Recently he had invented a reinforced cement glazing bar, which is now upon the market.

Mr. Potter was one of the earliest writers on concrete, and was often described as "the Father of Concrete." His first book, entitled *Concrete*, was published in 1877, and his last one in 1908. He also wrote a book on "Silo Construction" in 1886, and another on "Small Holdings" in 1910.

He was one of the founders of the Society of Estate Clerks of Works, of which he was the Secretary from 1888 until his death.

PERSONAL.

Mr. D. M. Watson, B.Sc., Assoc.M.Inst.C.E., has entered into partnership with Messrs. Dodd & Dodd, M.M.Inst.C.E., Civil and Consulting Engineers, of County Chambers, Corporation Street, Birmingham. Mr. Watson has had both American and English experience of professional work, while Messrs. Dodd & Dodd have had some 35 years of wide and varied experience in the design and construction of civil engineering work both in England and abroad. The name of the new firm is Dodd, Dodd & Watson.

CHANGE OF ADDRESS.

The British Reinforced Concrete Engineering Co., Ltd., inform us that on and after November 11th their London offices will be 4, Iddesleigh House, Caxton Street, Westminster, S.W.1.

TRADE NOTES.

Floors to Coffee Plantations.—A question which has been exercising the minds of owners and managers of coffee plantations is the improvement of Patio floors, and a few observations on this subject may prove helpful.

The following are the essential qualities of a coffee drying ground. The floor must be impervious to the dampness which rises from the earth. The surface must be smooth so as not to abrade the coffee beans, and finally it must be hard, to withstand the wear resulting from the continual raking about of the beans whilst drying.

A great advantage is to have the floor coloured black, as this greatly hastens the drying of the beans by absorption and subsequent radiation of solar heat.

A type of floor which has found much favour is tiles laid upon a concrete bed, but even better and more economical is an impervious floor of Portland cement which is coloured black by the admixture of chemicals. This innovation was first suggested by Messrs. Kerner-Greenwood & Co., Ltd., King's Lynn, England. The floors are made impervious to dampness by the addition of a small percentage of their powder " Pudlo."

The colouring of Portland cement removes one of the greatest objections to the architectural (as distinct from engineering) use of this material, for it provides a decorative treatment which is peculiarly suited to warm climates—witness the extensive use of colour treatment in the façades of their buildings by the ancient Greeks.

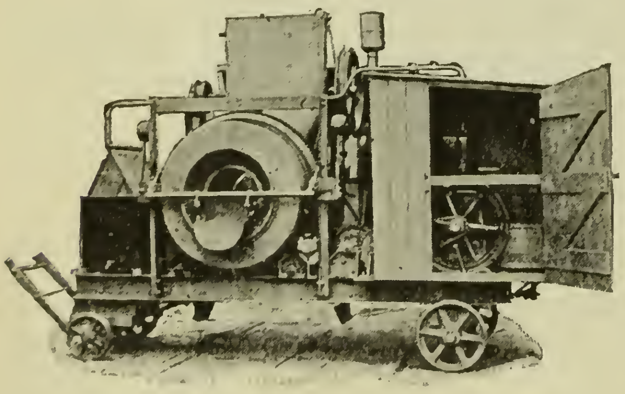
We understand that Messrs. Kerner-Greenwood & Co., Ltd., have compiled a leaflet in which full proportions and directions for the colouring of cement are given, and they will, on request, be pleased to send a copy, free, to any reader of this journal.

PUBLICATIONS RECEIVED.

The Review of the Foreign Press.—The various reviews appearing under the above heading will be continued as a public service, under the editorship of Capt. Barber, who is assisted by an Advisory Council. These reviews first appeared during the war, and have proved exceedingly useful in giving a brief survey of the Press of all countries regarding technical questions, political affairs, and questions relating to Finance, Industry, Commerce and Social work. The Technical Review appears fortnightly, and the Economic and Political Reviews appear once a week.—Publishing Office: Watergate House, Adelphi, W.C.2.

PUBLISHER'S ANNOUNCEMENT.

A French publication in concise form is to be published early in 1920 for the use of engineers, architects, contractors, students, etc., containing useful notes, tables and calculations relating to reinforced concrete construction. The book is edited and published by Mons. Muzak, Rue de la Loi 50, Brussels. (Price 15 francs.)



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